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CONTROL OF SNAILS BY THE REDEAR (SHELLCRACKER) SUNFISH

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CONTROL OF SNAILS BY THE REDEAR (SHELLCRACKER) SUNFISH 1/

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Abstract

Biological control of two species of native pond snails, Physa sp. and Lymnaea sp., was attempted using the redear sunfish, Lepomis microlophus (Gunther). The feeding habits of redears were studied under varied conditions in aquaria. Snails alone were fed to redears at rates up to 8 percent of their body weight for seven days, and with few exceptions, all were eaten. When snails and midge (Chironomidae) larvae were fed at rates of 2 and 6 percent respectively, redears ate 73.3 percent of the snails offered. When the feeding rate of snails was doubled, fish ate 70 percent of the snails offered. Snails comprised 39.1 percent of the food eaten by redears when 16.6 percent of the available food consisted of snails and 83.4 percent consisted of dragonfly nymphs. When 28.6 percent of the food given consisted of snails, they made up 48.6 percent of the total food eaten. Snail populations in plastic pools containing soil and six species of aquatic plants were reduced 80.6 to 98.9 percent within one day following the introduction of redear sunfish. The stomach contents of 63 redear sunfish taken from natural waters sparsely populated with snails were analyzed. Snails comprised 8.5 percent of the contents of the 49 stomachs containing food.

1/ Based on a Master of Science thesis submitted to the graduate faculty of Auburn University. This investigation was supported by PHS research grant E-2478 (C-1) from the National Institute of Health Service.

IX/E-11

UTILISATION DU REDEAR (SHELLCRACKER) SUNFISH 1/ (LEPOMIS MICROLOPHUS) POUR L'ELIMINATION DES ESCARGOTS

Résumé

Le redear sunfish, Lepomis microlophus (Gunther), a été utilisé au cours d'expériences de lutte biologique contre deux espèces indigènes d'escargots d'eau douce, Physa sp. et Lymnaea sp. Les habitudes alimentaires des redears ont été étudiées dans diverses conditions en aquarium. Au cours d'expériences où les redears ont été alimentés en escargots seuls à raison de 8 pour cent de leur poids corporel par jour pendant sept jours, presque tous les escargots ont été mangés. Avec une alimentation composée d'escargots et de larves de moucherons (Chironomidae) à raison de deux et six pour cent respectivement, les redears ont mangé 73,3 pour cent des escargots. Lorsque la ration d'escargots a été doublée, les poissons ont mangé 70 pour cent de ceux-ci. Les escargots représentaient 39,1 pour cent des aliments consommés par les redears dans les cas où 16,6 pour cent de la nourriture disponible consistaient en escargots et 83,4 pour cent en nymphes de libellules. Lorsque les escargots représentaient 28,6 pour cent des aliments fournis, ils entraient pour 48,6 pour cent dans le total des aliments ingérés. Dans des bassins en plastique contenant de la terre et six espèces de plantes aquatiques, les populations d'escargots ont été éliminées dans les proportions de 80,6 à 98,9 pour cent en l'espace d'un jour après introduction de redear sunfish. Le contenu de l'estomac de 63 redear sunfish prélevés dans des eaux libres où les colonies d'escargots étaient rares a été analysé. Dans les 49 estomacs contenant de la nourriture, on a constaté que les escargots formaient 8,5 pour cent du contenu.

LUCHA CONTRA LOS CARACOLES MEDIANTE LA PERCA LEPOMIS MICROLOPHUS 2/

Extracto

Utilizando la perca Lepomis microlophus (Gunther) se intentó el combate biológico de dos especies de caracoles indígenas de los estanques, Physa sp. y Lymnaea sp. Se estudiaron los hábitos alimentarios de la mencionada carpa en distintas condiciones en acuarios. En primer lugar, diariamente durante siete días, se le proporcionó como alimento solamente caracoles en proporciones que llegaban al 8 por ciento de su peso corporal y con pocas excepciones fueron consumidos todos. Cuando se les proporcionó caracoles y larvas de mosquitos (Chironomidae) en la proporción del 2 y el 6 por ciento, respectivamente, las carpas consumieron el 73,3 por ciento de los caracoles suministrados. Cuando se duplicó la proporción de alimentación de caracoles, las carpas absorbieron el 70 por ciento de los mismos. Los caracoles representaron el 39,1 por ciento del alimento consumido por las carpas cuando el 16,6 por ciento del alimento disponible estaba constituido por caracoles y el 83,4 por ciento por ninfas de libélula. Cuando el 28,6 por ciento del alimento proporcionado consistía en caracoles, éstos representaban el 48,6 por ciento del alimento total absorbido. Las poblaciones de caracoles existentes en depósitos de plásticos que contenían suelo y seis especies de plantas acuáticas quedaron reducidas entre el 80,6 y el 98,9 por ciento en un solo día como consecuencia de la introducción de la carpa de referencia. Fueron analizados los contenidos estomacales de 63 carpas de esta especie tomadas de aguas naturales pobladas poco densamente con caracoles. Estos constituían el 8,5 por ciento del contenido estomacal de 49 estómagos con alimentos.

1/ Tiré d'une thèse de Master of Science présentée à la Faculté de l'Université d'Auburn. Ces travaux ont été subventionnés par une bourse de recherche PHS, E-2478 (C-1) accordée par les National Institutes of Health, Public Health Service.

2/ Basado en una tesis para Maestro en Ciencias (Master of Science) para la Facultad de la Universidad de Aurburn. Esta investigación ha sido apoyada con la donación para investigaciones del Servicio de Sanidad Pública E-2478 (C-1) de los Institutos Nacionales de Sanidad, Servicio de Sanidad Pública.

1 INTRODUCTION

Various species of snails are intermediate hosts of most digenetic trematodes of man, fish and other animals. The most important trematodes from a medical viewpoint are the blood flukes causing schistosomiasis in man. These flukes are a major cause of human illness and mortality in many parts of Africa, Asia and South America. Trematodes have been considered most vulnerable while in the snail host, whose control has been therefore the object of a vast amount of research.

Foremost among the many control measures attempted has been the use of chemicals toxic to snails. However, it is very difficult to control snails without adversely affecting the production of fish that may be the major source of animal protein for people in endemic areas of schistosomiasis. An added disadvantage of chemical control is the expense involved and the necessity of periodic treatment. The use of snail-eating fish offers the possibility of a lasting, economical and safe means of control. This possibility has received scant attention, although many fish feed to a greater or lesser extent upon snails. Michelson (1957) stressed the lack of significant work in his review of the literature dealing with the biological control of snails.

Hora (1952) recommended the culture of the catfish, Pangasius pangasius, where snails are a problem. According to his own observations and those of others, snails predominated in the diet of this fish. According to Hey (1946), the European tench, Tinca vulgaris, "favours a diet of snails" and will eventually eliminate them in certain permanent waters. He also found that the African lungfish, Protopterus, can subsist in aquaria entirely upon snails. De Bont and De Bont Hers (1952) reported that dense snail populations were eliminated from a small pond and greatly reduced in another by the African fish, Serranochromis macrocephala. They did not, however, give any information about the number or weight of fish involved. Oliver-Gonzalez (1946) observed the guppy, Lebistes reticulatus, to be very abundant in certain regions of Puerto Rico where the schistosome vector, Australorbis glabratus, was previously abundant, but is now no longer found. He reported that guppies in aquaria fed upon both egg masses and snails. A preference seemed to exist for those egg masses containing young snails ready to leave the egg masses. These fish were also observed to feed readily upon cercaria released by snails in aquaria.

Although some fishes native to endemic areas of schistosomiasis feed upon snails, they have not exerted any appreciable control. The possibility of using an exotic species, therefore, merits consideration. The redear sunfish, Lepomis microlophus (Gunther), appears to have the greatest potential of fish native to the South-eastern United States for controlling snails. For many years this fish was called shellcracker because of its habit of breaking the shells of molluscs before eating them. The food habits of this fish have received little detailed study; however, they are frequently reported to be malacophagous. Huish (1957) described the stomach contents of 69 redears taken from Lake George, Florida. Snails were found in 92 percent of the 36 fish examined that contained food, and they comprised 74.4 percent of the total volume of food eaten. Chable (1947) reported that snails were important in the diet of redear sunfish only in streams. Of the 96 fish examined from streams, 83 contained food. Snails were found in 97.6 of these fish, and each contained an average of 8.1 snails. Of the 13 fish taken from lakes only six contained food. Snails occurred in 66.7 percent, with an average of 1.3 snails per fish.

2 TEST ANIMALS

The redears used in these experiments were obtained from the Agricultural Experiment Station ponds of Auburn University, placed in stainless steel troughs provided with running water, and treated for the control of disease and parasites. Treatment consisted of a one-hour exposure to 10 ppm potassium permanganate followed by a six-hour exposure to 15 ppm formalin. All aquaria and nets and pans used in handling fish in the laboratory were first disinfected with either chlorox or roccal.

Snails of the genera Physa and Lymnaea, midge larvae of the subfamily Tendipedinae, and dragonfly nymphs of the suborder Anisoptera were collected from ponds and streams in the vicinity of Auburn, Alabama. Dragonfly nymphs were obtained by dragging a scoop net along pond bottoms, while snails were hand-picked from submerged vegetation or pond bottoms. Midge larvae were collected with "multiple-plate samplers" described by Hester and Dendy (1962).

The cases containing midge larvae were scraped from the plates with a spatula into a bottle half-filled with water. This bottle was shaken vigorously to separate the cases from each other and to loosen as much debris as possible. The contents of the bottle were then poured into a metal pan with a screen bottom and washed. After being washed, the cases containing the midge larvae were spread on a screen stretched over a shallow pan that was completely filled with water. A gooseneck lamp was then placed about 3 inches (76.2 mm) above the screen, and under these conditions many larvae soon left their cases and dropped into the pan where they attached themselves to the bottom. The water was then poured out, and the larvae were scraped with a spatula.

Midge larvae were measured volumetrically in a graduated cylinder. Snails and dragonfly nymphs were placed on paper towelling to absorb excess moisture and were then counted and weighed.

3 LABORATORY TESTS

Laboratory tests were conducted in 40-litre aquaria containing tap water that was dechlorinated by passage through an activated charcoal filter. The water in each aquarium was aerated with compressed air. The aquaria were equipped with galvanized or aluminium wire screen covers to prevent the snails from crawling above the water line, where they would have been unavailable to the fish. These covers were suspended from the ends of the aquaria, and extended an inch (25.4 mm) or more below the water line. A small hole was made near one end of each cover for the aeration hose.

Feeding tests were conducted in these aquaria to determine the extent to which redears would eat snails under various conditions. From eight to 16 fish, with one fish per aquarium, were used in each test. The rate of feeding was based on the body weight of the individual fish. Each fish was weighed and fed a specified percentage of its initial body weight daily for five to seven days.

3.1 Utilization of snails by redears in the absence of other food

Redears having an average weight of 97.0 grams were offered snails at rates of 1, 2, 3, and 4 percent of their body weight daily for six days. Each feeding rate was replicated four times; however, one fish fed at the rate of 2 percent died during the test. In order to determine if redears utilized both genera of pond snails commonly found in Alabama, one-half of the fish fed at each rate received physid snails, and one-half received lymnaeid snails.

During this test, each fish was offered from 4.2 to 25.2 grams of snails. Natural mortality of snails was negligible and both genera of snails were eaten readily. Except for one fish fed at the rate of 4 percent, all fish ate all snails offered them.

In a similar experiment, higher rates of feeding were included. Redears that had an average weight of 107.2 grams were offered snails at rates of 1, 2, 3, 4, 5, 6, 7, and 8 percent of body weight daily for seven days. Each feeding rate was replicated twice, but one fish fed at the rate of 7 percent died during the test. Because both kinds of snails were eaten readily in the previous experiment, these snails were not segregated by species.

The maximum total weight of snails fed to a fish during this test was 69.3 grams. Natural mortality of snails was negligible except in two aquaria containing fish fed at rates of 5 and 7 percent. In these two aquaria natural mortality of snails amounted to 22.1 and 10.5 percent respectively of the total weight offered to the fish. None of the snails offered were refused by 13 of the fish, but not all were actually eaten since dead and occasionally living snails were found with all or most of the shells removed. The killing of the snail without consuming it usually occurred with higher rates of feeding.

3.2 Utilization of snails by redears in the presence of other natural foods

In the preceding experiments redears readily fed upon snails in the absence of other food. In order to determine the extent of snail consumption when other foods were available, redears averaging 36.2 grams in weight were fed snails and midge larvae daily for six days. Feeding rates, each replicated four times, were as follows: 2 percent snails; 2 percent snails plus 6 percent midge larvae; 4 percent snails; and 4 percent snails plus 6 percent midge larvae (Table I).

Redears that were offered snails alone at the rate of 2 percent daily ate 99.4 percent of them, but in the presence of midge larvae at the rate of 6 percent, snail consumption was reduced to 73.3 percent. When snails alone were offered at a rate of 4 percent, the fish ate 89.1 percent of them, but only 70.0 percent were eaten when midge larvae at the rate of 6 percent were also available. Although snail consumption decreased in the presence of midge larvae, it is considered significant that the fish continued to eat most of the snails.

The data obtained in this test had a serious limitation in that the extent redears fed on midge larvae was not determined. The lower utilization of snails in the presence of midge larvae was probably the result of the presence of this additional food; however, some fish ate considerably less than others. In this test, one fish offered snails only at the rate of 4 percent ate less snails than did six of the eight fish offered snails plus midge larvae. Whether part of this decreased utilization of snails was caused by listless feeding is not known.

Another factor that created a bias was the greater availability of the midge larvae as used in this test. In their natural environment, these larvae construct cases from sand and debris on submerged objects, often in places inaccessible to fish. Under such conditions, they are probably not as available to the fish as the midge larvae offered these fish.

Another natural food organism used with snails, and one allowing an estimate of its utilization by fish in aquaria, was the dragonfly nymph. Redears weighing an average of 90.8 grams were offered dragonfly nymphs at the rate of 10 percent plus snails at either 2 or 4 percent daily for five days. Each feeding rate was replicated four times.

During the course of this test, the remains of 431 dragonfly nymphs and 18 snails were removed. Many of the former were not intact, and all that remained of some of the latter was an empty shell. Observations indicated that dragonfly nymphs eaten by fish were consumed in their entirety, and that the shells of snails eaten were crushed and spit out. It was therefore concluded that these partially eaten nymphs and empty snail shells were the result of predation by dragonfly nymphs. In order to estimate the original weight of organisms eaten by dragonfly nymphs, an average weight was computed from the total numbers and weights of nymphs and snails used in this test.

With one exception, all fish ate more dragonfly nymphs than snails (Table II). Although the more abundant item was eaten in greater amount, the selection of food was not random. Snails made up 16.6 percent of the total food offered when fed at the rate of 2 percent; however, they comprised an average of 39.1 percent of the food eaten by

Table I

The utilization of snails by redears in aquaria

Daily feeding rate in percentage of body weight		Utilization of snails in percentage of total weight offered			
Snails	Midge larvae	Natural mortality	Not eaten	Eaten by fish	Average
2	0	0	0	100	
2	0	2.4	0	97.6	
2	0	0	0	100	
2	0	0	0	100	99.4
2	6	41.7	0	58.3	
2	6	5.6	0	94.4	
2	6	54.8	0	45.2	
2	6	4.8	0	95.2	73.3
4	0	5.1	38.5	56.4	
4	0	0	0	100	
4	0	0	0	100	
4	0	0	0	100	89.1
4	6	12.7	34.3	53.0	
4	6	33.3	0	66.7	
4	6	1.0	0	99.0	
4	6	9.0	29.5	61.5	70.0

Table II

The utilization of snails and dragonfly nymphs by redears in aquaria

Daily feeding rate in percentage of body weight		Total food in grams				Percentage of total food made up of snails		
		Snails		Dragonfly nymphs				
Snails	Dragonfly nymphs	offered	eaten	offered	eaten	offered	eaten	Average
2	10	13.0	12.0	66.0	27.8	16.6	30.2	
2	10	8.0	6.0	40.5	8.1	16.6	42.6	
2	10	10.0	9.9	51.0	15.1	16.6	39.6	
2	10	10.0	3.6	49.5	4.6	16.6	43.9	39.1
4	10	13.5	8.5	34.0	11.7	28.6	42.1	
4	10	18.0	7.3	45.5	7.4	28.6	49.7	
4	10	15.5	13.1	38.5	14.3	28.6	47.8	
4	10	21.5	15.0	53.5	12.3	28.6	54.9	48.6

fish fed at this rate. When fed at the rate of 4 percent, they comprised an average of only 28.6 percent of the total food offered, but 48.6 percent of the total food eaten. The "forage ratios" of snails and dragonfly nymphs, as proposed by Hess and Swartz (1940) were calculated and a significant difference was found indicating a preference for the former over the latter.

The importance of not determining the extent of midge larvae utilization in the preceding experiment is illustrated by Table II. One fish that was fed snails at the rate of 2 percent ate only 3.6 of the 10.0 grams offered it, which was considerably less than that eaten by the other three fish fed in like manner. Another fish that was fed snails at the rate of 4 percent ate only 7.3 of the 18.0 grams offered it, which was also considerably below average. Yet snails comprised a higher than average percentage of the diet of these two fish because of a low total consumption of food.

4 FIELD EXPERIMENTS

A series of 23 plastic pools that contained established snail populations was used to determine the effect of redears on snails in the presence of weeds. All pools contained several centimetres of soil in the bottom and the following plants: Pithophora sp.; naiad, Najas guadalupensis; pondweed, Potamogeton diversifolius; water hyacinth, Eichhornia crassipes; duck weed, Lemna minor; and water stargrass, Heteranthera dudia.

In order to determine if size of fish was a factor in the utilization of snails for food, two sizes of fish were used. The average weight of the larger fish was 99.7 grams and of the smaller fish 36.3 grams. Pools were stocked at each of the following rates: one large fish, three large fish, three small fish, and eight small fish per pool. Each stocking rate was replicated four times. Seven pools were designated as controls and received no fish.

The sides of these pools were translucent and allowed the passage of a considerable amount of light. Because of this, and the clearness of the water, snails on the sides of these pools could be readily seen and counted. The snails on the sides of each pool were counted immediately prior to the stocking of fish and daily afterwards for four days. The final observation was made on the tenth day after the fish were stocked. (See Table III below):

Table III

The average percentage reduction of snails on the sides of plastic pools

Number of pools	Number stocked	Average percentage reduction of snails at various intervals after the stocking of redears				
		Days : 1	2	3	4	10
7	0	12.1	22.2	30.4	29.7	38.1
4	1	84.9	94.9	97.2	99.4	99.2
4	3	80.6	96.0	97.2	98.4	96.9
4	3	93.2	96.8	98.3	98.9	99.4
4	8	98.9	99.6	99.3	100.0	99.7

Prior to the stocking of fish, the number of snails found in the 23 pools ranged from 30 to 207, with an average of 111.5 per pool. Although snails decreased in all pools during the 10 day test period, this decrease was especially prominent in the pools containing redears. On the first day after the fish were stocked two pools were found without any snails on the sides. The greatest number of snails observed at this time in any pool stocked with fish was 48. At the end of the 10 day test, the number of snails observed ranged from 0 to 9 in pools stocked with fish, and from 20 to 119 in the seven controls. No snails were found in eight of the 16 pools stocked with redears, and only one pool contained more than two snails. The average reduction of snails on the sides of these pools was 98.8 percent in the redear pools and 38.1 percent in the controls.

The lower stocking rate used was high enough to practically eliminate snails from the sides of these pools within 10 days. A statistical analysis of variance of the data obtained at this time indicated no significant difference in snail control between either the two sizes of fish or between the two stocking rates. The data obtained on the first day after fish were stocked also indicated no significant difference between the two stocking rates. However, at this time the smaller fish had reduced the number of snails to a significantly greater extent than had the larger fish. This difference may have been due to a temporary interruption in the feeding of some of the fish as a result of their being handled and placed in a new environment. An effect of this type would be more noticeable in the larger fish since smaller numbers were used.

Although no snails could be found on the sides of some pools stocked with redears, it is not considered that redears totally eliminated snails in any pool during this test. Upon close observation, a few snails could usually be found in the vegetation floating on the water's surface; however, they were almost completely eliminated in all cases upon venturing outside the heavy weed growths to the sides of the pools.

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