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ids), chopped earthworms, canned or fresh shellfish, scraped, or liver, and very small cubes of fish may all be tried, but exercise must be exercised in the feeding of the above. Tuna, sardines, and oily canned fish should never be food in the small aquarium.

to Feed and How Much

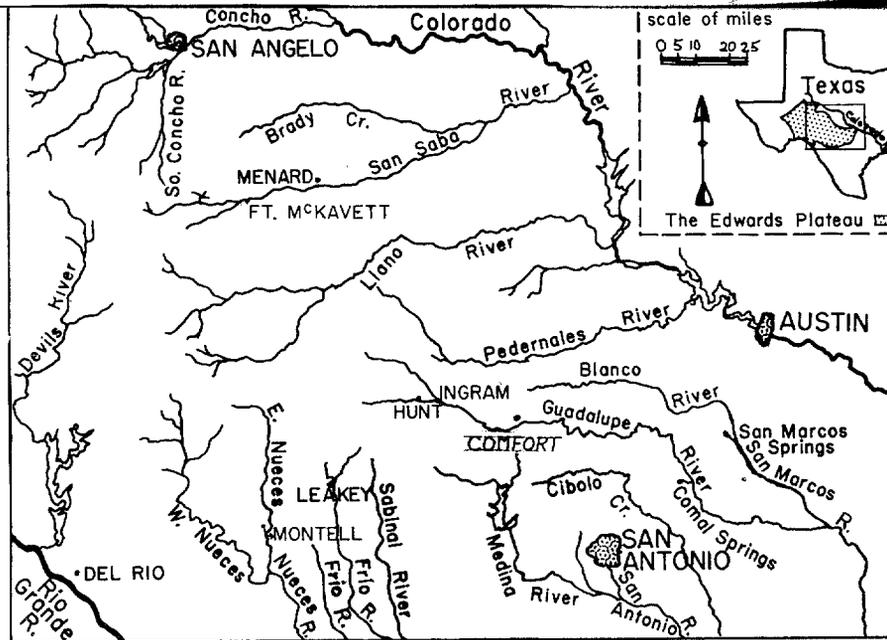
Problem of how often to feed and how much presents many difficulties. It comes down to setting fixed rules. Here common sense, observation and experimentation must be your guides.

Regarding the size of your specimens to be considered; however, the most fundamental should be their size. The majority of very young fishes in their natural habitat eat almost constantly. In the home aquarium this constant feeding would be difficult and a substitute must be duplicated. The majority of fishes will do well on two or three feedings daily. For older fishes one feeding should prove sufficient. Inexpensive specimens should be considered, and fishes — like people, eh, Rollo? — do not eat too much if given the opportunity. In extreme cases fishes have been known to kill themselves from overfeeding. On the other hand fishes in the aquarium will sometimes go on a strike. In such cases either a change in diet or a short period of starvation (a combination of the two) is

What must be remembered about feeding everything that goes into the tank must have to come out, either as uneaten food or as fecal matter. The tank must be watched closely and uneaten food (as it is alive), and fecal matter must be removed daily.

Rule: DO NOT OVERFEED. On the other hand avoid starving your fish. If in doubt strive for a happy fish. If that has you worried, Rollo, remember this: the above is meant as the general fundamentals; a

(continued on page 32)



A Method of Breeding and Raising

THREE TEXAS DARTERS

Kirk Strawn

University of Texas

PART II

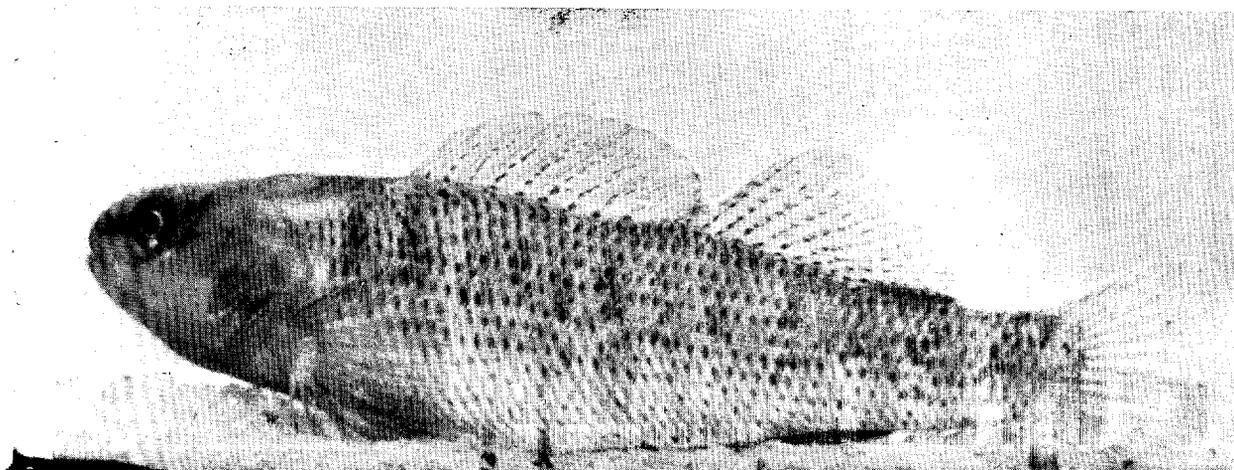
THERE IS LITTLE available information on the breeding habits of darters. Most published accounts are of field observations or aquarium observations made on ripe, freshly caught, wild fish. There are no accounts stating how to bring darters into breeding condition or, except for Fahy's recent paper (1954), presenting means of obtaining repeated spawnings from a single pair.

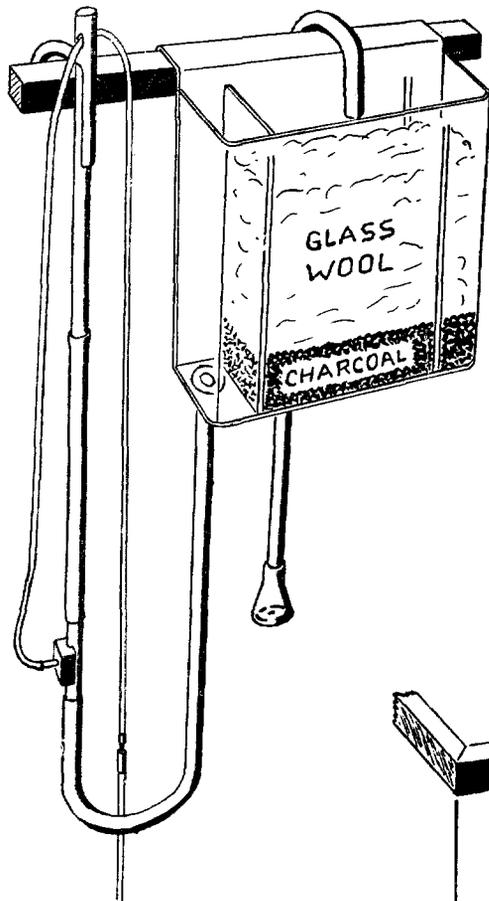
Map: Rivers of the Edwards Plateau in Texas, sketched by the author.

Proper temperature and food are essential for repeated spawnings.

A pair of greenthroat darters will spawn repeatedly when kept at temperatures ranging from 60 (and probably lower) to 74° F. Between 75 and 80° F. the females stop laying and if kept in the 80's for long they require a stay of about ten days to three weeks at breeding temperatures before they will

Photo: A male Rio Grande darter, *Etheostoma grahami*, 2 3/8 inches in total length. Taken from Devil's river. Photo: John S. Mecham.





NOW 3 SIZES

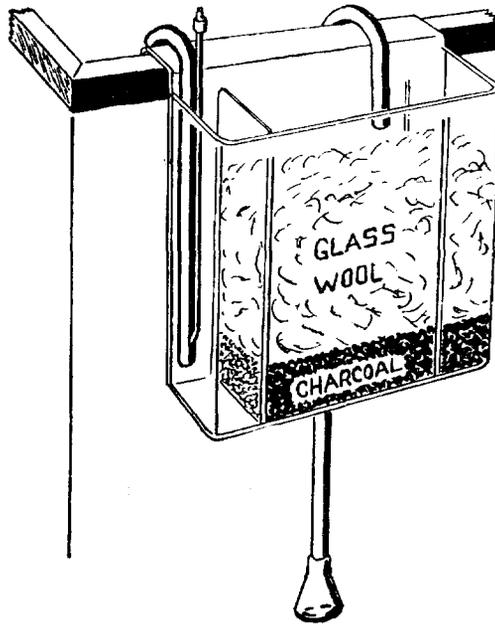
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spawn again. Though a show little change in frequency at different temperatures, they are greatly slowed down by lower temperatures. At 72 to 74° F. they will spawn every four and five days while in the low 60's spawning one-half as frequent. Both Rio Grande and Rio Grande darters spawn in the low 70's and high 70's. At Marcos Springs the four darters spawn the year around in the low 70's and high 70's. At 72° F.

Frequent spawning results from feeding of suitable food. This is one that the darters eat before them twenty-four hours. Houston dwarf white worms and tubifex larvae both fill the



tubifex worms have not been used to try, I believe they would be excellent. *Daphnia magna* can be used in sufficient quantities and used as a supplement rather than main fare. Brine shrimp have the advantage of not living in the water and are ignored by the throat darters when larger than they are able. On the bottom of the

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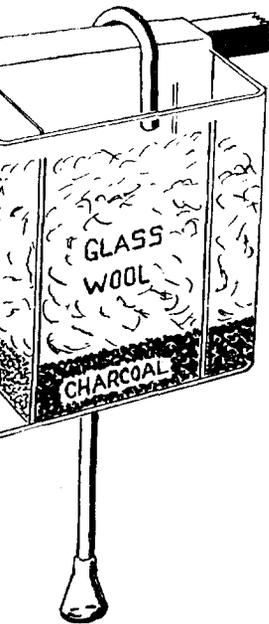
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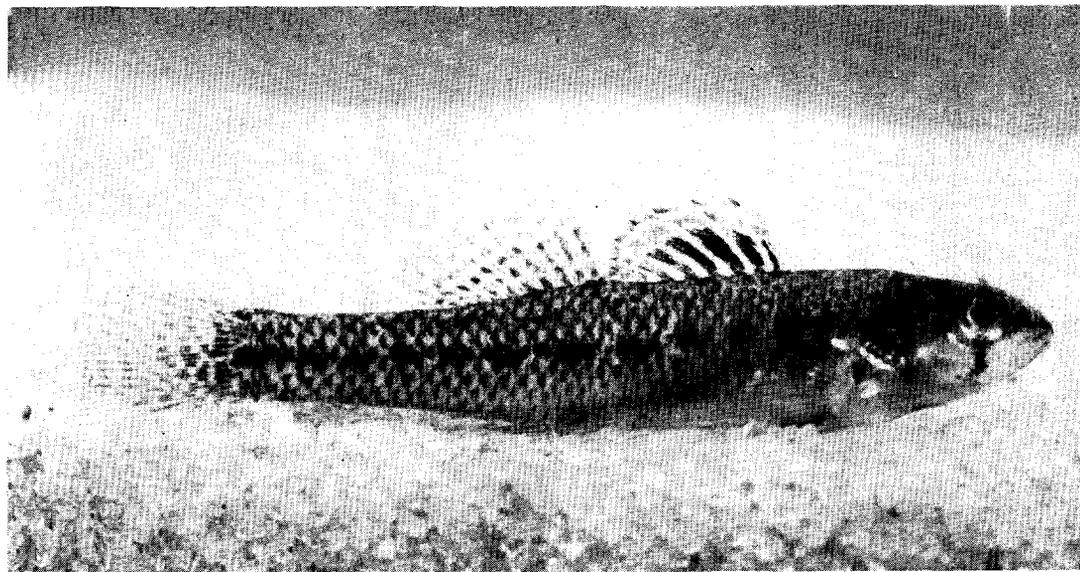
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spawn again. Though a few females show little change in frequency of spawns at different temperatures, most females are greatly slowed down by lower temperatures. At 72 to 74° F. a good female will spawn every four and one-half days while in the low 60's spawnings are about one-half as frequent. Both the fountain and Rio Grande darters spawn readily in the low 70's and high 60's. At San Marcos Springs the fountain darter spawns the year around in water ranging 3 to 5 degrees above and below 72° F.

Frequent spawning result from heavy feeding of suitable food. The best food is one that the darters eat avidly and is before them twenty-four hours a day. Houston dwarf white worms and mosquito larvae both fill the bill. Though

the darters do most of their feeding, drosophila larvae die in an hour or so and the darters will not touch a drowned larvae. Mass deaths of darters frequently occur in tanks with dead and rotting drosophila larvae on the bottom even though the water is well aerated and does not appear to be foul. It is possible that the greenthroat and Rio Grande darters would spawn on a diet of either one of the wet meat base foods advertised in the aquarium magazines or on homemade Gordon's formula (Gordon, 1955). The greenthroat darter stays fat and lives for months in a large community tank even when little besides good quality dried food is fed. The fountain darter, on the other hand, is very slow to take dead food.

Even though darters spawn readily



tuberfex worms have not been available to try, I believe they would also prove excellent. *Daphnia magna* are not eaten in sufficient quantities and should be used as a supplement rather than as the main fare. Brine shrimp have the disadvantage of not living long in fresh water and are ignored by adult green-throat darters when larger food is available. On the bottom of the tank, where

on a dwarf white worm diet, dwarf white worms alone are not always a satisfactory diet. A condition similar to the blue sac disease of trout (Davis, 1953) appears to be associated with the feeding of dwarf white worms. Frequently all or part of a spawn of eggs will hatch into larval fish that have large

Photo: A male fountain darter, *Etheostoma fonticola*, 1 1/4 inches in total length. Taken from San Marcos springs. Photo: John S. Mecham.

yolks which are not absorbed. These larvae do not feed and die in about a week. The addition of mosquito larvae to the parents' diet minimizes the production of these abnormal larvae.

A pair of darters can be successfully spawned in a five gallon tank. After several spawnings a female Rio Grande or greenthroat darter may look chewed and should be removed from the tank and given a rest or else the male will eventually kill her. Providing two or three females so that the male's attention is divided, using a larger tank, and furnishing rock piles and plants for shelter all help prevent torn fins on the female.

Freshly caught wild darters usually produce yellow eggs. In contrast, darters fed white worms produce colorless eggs. The addition of mosquito larvae or brine shrimp to the diet puts some color into the eggs but none of the laboratory stocks have produced the beautiful bright yellow eggs found in nature. As the embryo develops, yellow eggs fade and become nearly colorless.

The number of eggs produced varies in different spawnings. For example, a pair of greenthroat darters from the West Frio River fed a combination white worm and *Daphnia magna* diet, given constant light and kept in a five gallon tank at 62 to 68° F. laid on the glass wool of an open bottom filter 13 batches of eggs during a 63-day period numbering 47, 70, 100, 109, 84, 61, 86, 87, 86, 96, 75, 106, and 108. Large females from the Guadalupe and Colorado River Systems frequently lay two or even three times as many eggs at a time while Rio Grande females lay somewhat fewer eggs.

Darters may bury their eggs (Winn, 1953), lay them under a rock, a shell, etc. and guard them (Rainey and Lachner, 1939 and Atz, 1940) or lay eggs here

and there on vegetation (Fahy, 1954) and other solid objects. The three dealt with in this paper are of the latter type.

The male courts the female on the bottom of the tank. When the female is ready to spawn she swims, followed by the male, up to an object upon which she deposits her adhesive eggs. These darters lay their eggs on the side of the tank, particularly the corners, on aquarium filters, or on plants. If filamentous algae is present in the aquarium, the eggs of the fountain and greenthroat darters are deposited almost exclusively on it. A mass of white fluffy glass wool is also a preferred spawning site. The fountain darter lays its eggs almost exclusively in the upper half of the aquarium and will ignore glass wool in the lower half of the tank. In contrast the greenthroat darter will spawn almost exclusively in the lower half provided the glass wool is confined to the lower parts of the aquarium and no filamentous algae is present. The Rio Grande darter does not show as strong a preference for glass wool as the greenthroat darter and even with only this spawning medium present it frequently lays most of its eggs on solid objects such as under and on top of rocks and on the sides of the aquarium. The fountain darter usually deposits eggs singly or in twos or threes. The Rio Grande and the greenthroat darters from the Nueces River System generally lay less than ten eggs to a mass while greenthroat darters from the Guadalupe and Colorado River Systems frequently lay 30 or more eggs in one spot.

No care is taken of the eggs except that the dominant male greenthroat darter chases other males from the females' preferred spawning site.

Few if any of the eggs laid on glass wool or filamentous algae are eaten. Eggs laid on the sides of the tank frequently disappear and it is possible that

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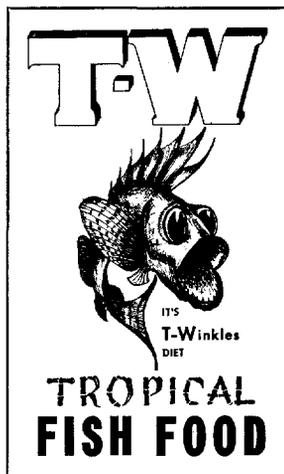
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the parents eat them. They de
newly hatched larvae. When
and filamentous algae are th
fountain darters will hatch
to maturity in an aquarium
with adults. Frequently a
Grande darters develop at l
as the free-swimming stag
throat darters rarely survive
hatching when the eggs are
the parents. If the aquarist
raise a batch of young, he s
either the eggs or the pare
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the parents eat them. They definitely eat newly hatched larvae. When the plants and filamentous algae are thick many fountain darters will hatch and grow to maturity in an aquarium crowded with adults. Frequently a few Rio Grande darters develop at least as far as the free-swimming stage. Green-throat darters rarely survive much past hatching when the eggs are left with the parents. If the aquarist wishes to raise a batch of young, he should take either the eggs or the parents out of the breeding tank. The easiest method is to furnish the fish with glass wool as a spawning medium and then to remove the glass wool and eggs to a white enamel dish pan. If preferred, the eggs can be picked off the glass wool by hand and the glass wool discarded. I prefer a dish pan to an aquarium because the eyed eggs and young are very easily observed against a white background. Once the fry are well started they can be transferred to a rearing tank.

Eggs laid on plants and the sides of the aquarium are easily removed with a medicine dropper or better yet with a piece of glass tubing inserted into a niter starting bulb. Eggs are soft and easily ruptured when first laid and should be given a few hours to harden before they are knocked loose and removed. The breeder should not wait until they are ready to hatch before removing them because an enzyme softens the egg shell prior to hatching. The eggs of many fish (Davis, 1953) have a critical period in which they are easily damaged by rough treatment. After the first day or two salmon and trout eggs must be handled with extreme care until they become eyed. Darter eggs do not seem to be killed or damaged by handling during this period.

The hatching pan should contain clean, hard water. At 72-74° F. the eggs of the green-throat darter hatch between 4 and 6 days after being laid. at 67-69°

F. they hatch in 6 to 9 days, and at lower temperatures they are much slower to hatch. A few eggs turn white and become fungused before the eyes of the developing embryos can be seen. These eggs are probably defective before fungus attacks them. Dead eggs should be removed because fungus may spread to a good egg when it is in contact with an infected one and also when aeration is not used dead eggs tend to foul the water. Aeration insures good hatches, particularly at high temperatures. Un-aerated eggs at 72-74° F. frequently die just prior to hatching and the larvae may prove less vigorous than those hatched with aeration. Good hatches can be obtained without the use of dyes such as acriflavine and methylene blue.

If the female spawns readily but none of the eggs become eyed the male may be infertile and a different male should be used. If the eggs still fail to develop the fault may lie with the female. Frequently the last spawn before one of a pair dies fails to hatch. Very few of the eggs fathered by a one-eyed male Rio Grande darter proved fertile. Perhaps he could not see well enough to successfully follow the female during spawning.

How soon after hatching the larvae will accept their first food and at what age they will be large enough to eat a given size food is dependent on temperature. They develop more slowly at low temperatures and faster at higher temperatures. Newly hatched fountain darters, at about 70° F., need infusoria for about a week before they can take newly hatched San Francisco Aquarium Society brine shrimp. Most hatches of Rio Grande and greenthroat darters can be successfully raised without using infusoria and will feed on brine shrimp within two to four days after hatching. However, larvae from small eggs require in-

(continued on page 31)

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To be continued)

Silver Dollars

(continued from page 5)

the market after an absence of more than ten years — at least we hadn't seen any since before World War II.

Another easily recognized silver dollar is *Mylossoma aureum*. The shape of its body and anal fin is quite different from any of the other silver dollars imported, and the orange color of the anal is also a distinguishing feature.

Quite recently the New York Aquarium obtained the first specimen we had ever seen of a close relative of the silver dollars, which in appearance and behavior seems to bridge the gap between the more or less peaceful, vegetarian or snail-eating silver dollars and their savage carnivorous relatives, the piranhas. This is *Catoprion mento*, from the Guianas and the Amazon. Our fish had grown up in one of the tanks of Mr. Sol Soberman, a local fancier of unusual tastes and abilities. Although it is a good five inches long (total length) and is well equipped with sharp teeth, it will not eat anything larger than a female guppy. Larger fish, like killies, are sometimes chased, but no attempt is made to bite them in half or to take chunks out of them the way piranhas do. Instead *Catoprion* swallows them whole, with a motion so fast that the eye cannot follow.

One reason the silver dollars are hard to identify and name properly is that some of them change quite a bit as they grow up. Small spotted ones usually lose their spots, for example, and the shape of the body alters in important, but hard-to-describe ways. Males of some species develop falcate (sickle-shaped) anal fins. But even if you can't name them, you can keep them.

Texas Darters

(continued from page 17)

fusoria to tide them over until they can

take brine shrimp. If they do not eat brine shrimp within a week, close inspection usually reveals abnormally shaped yolks, indicating blue sac disease. Darter fry have to feed for several days on San Francisco brine shrimp before they are big enough to eat the larger Great Salt Lake brine shrimp.

If a brine shrimp smaller than the San Francisco one is available it would prove an advantage in starting darters. The sooner they will eat brine shrimp, the faster they will grow. Little darters require at least two brine shrimp feedings a day and three widely spaced feedings are better than two. The warmer the water they are raised in, the more often they should be fed.

The addition of a couple of strands of *Elodea* or a pinch of *Riccia* or a similar plant, some pond snails, a few dozen daphnia and some limestone to the rearing pan are all valuable aids in raising the little fish. Aquarists cannot seem to agree as to why plants are beneficial, but most of us agree that vigorously growing plants are desirable. The snails clean up the dead uneaten food, the daphnia are excellent filters and keep the water clear, and the limestone tends to keep the water hard. Pond snails are safe with living darter eggs and larvae and perform a useful function by eating dead eggs and larvae that otherwise are sources of infection for viable eggs. Dead brine shrimp and mulm should occasionally be siphoned off the bottom of the pan and part of the water replaced with fresh hard water. About two weeks after hatching the fry settle to the bottom and are ready for dwarf white worms. The young fish grow faster and fewer die when brine shrimp are continued as a supplement. Young feeding on white worms have white bellies in contrast to the orange bellies of those fed brine shrimp. Small *Daphnia magna* are eaten somewhat later.

A few of the small fish will die trying to swallow too large a daphnia if insufficient small daphnia are available. The presence of white worms in the tank prevents this type of loss. Darters continue to grow well on a brine shrimp, daphnia and Houston white worm diet. My first aquarium raised fountain and greenthroat darters spawned by the age of eight months. With improved feeding techniques I have gotten greenthroat darters to spawn by five and one-half months, Rio Grande darters by six months, and hybrids between greenthroat and Rio Grande darters to spawn by seven months of age.

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Marine Aquarium

(continued from page 10)

little experimentation should provide you with the best system to follow.]

It is quite possible and, in most cases, does no great harm, occasionally to leave your specimens without food for several days. In fact, if occasion should arise when it might be necessary for you to be absent for a few days, it is better to leave them quite without food than to have some inexperienced neighbor come in to feed them.

[Which about concludes this session. Rollo! Any questions- *What?* No, Rollo, I do not think goldfish wafers would make good food for marine fishes, although I have never tried it. Let us know when *you* do, will you? In the meantime you are all set except for the inhabitants of your aquarium. In the next issue we will take up COLLECTING.]

LETTERS

A column of questions and answers for readers. Those questions which can find the answer in standard books will not be considered. Only interesting correspondence will be published. No reply by mail to persons in the less a stamped, self-addressed enclosed.

From: Mel Ho Chan
 San Francisco, California

Here are some questions which puzzled me for some time. I appreciate it very much if you can shed some light on them.

- (1) How is Innes pronounced?
 REPLY: *Innes is pronounced Innes.*
- (2) In determining the age of a fish, you count from the time they are laid or when they hatch?



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