a very high rate (up to 1000 per second) with a minimum expenditure of muscular energy. The high efficiency of this mechanism permits the male cicadas to emit a large volume of sound for a long period of time (1 to 2 weeks) despite a total lack of food intake during that time. The behavioral significance of this sonic activity has recently been discussed by Simmons *et al.* (*2*); the main functions are the attraction of mates, the separation of the different species within a brood, and the repulsion of avian predators.

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References and Notes

1. R. D. Alexander and T. E. Moore [*Univ. Mich. Zool. Misc. Publ. No. 121* (1962)] report a sound level of 96 db at a point 20 feet (6 m) from a mass of *M. tredecassini*.
2. J. A. Simmons, E. G. Wever, J. M. Pylka [*Science* **171**, 212 (1971)] measured sound levels on the ground beneath cicada-filled trees as 800 dyne/cm² and estimated the level within the swarm as 1000 dyne/cm² or more.
3. J. W. S. Pringle, *J. Physiol. (London)* **124**, 269 (1954). In the genera studied by Pringle the tymbals were not ribbed, but were smooth domelike structures, "clicked" in and out at a rate high enough to produce a sustained sound.
4. A preliminary presentation of these data was made at the American Physiological Society meetings in Bloomington, Indiana, on 1 September 1970.
5. The Pitran force transducer (Stow Laboratories, Hudson, Maine) is a pressure-sensitive transistor employing a piezoelectric sensing element. Sensitivity of the models used (PT-2, PT-5) is of the order of 1 volt/g force, and the mechanical self-resonance frequency is in excess of 100 khz.
6. The modified transducers, with attached wire hooks, could easily follow ultrasonic vibrations at 30 khz, and had a frequency response essentially flat over the range of interest.
7. Nerve stimuli were delivered through PE-10 tubing filled with mammalian Ringer solution. Electromyographic recordings from the tymbal muscle were also made with these electrodes. Stimulation of the thoracic ganglion was done with a pair of fine needle electrodes. Stimulus durations were 0.1 to 0.5 msec.
8. Neurophysiological studies were begun, but no useful results were obtained before the brood died off. S. Hagiwara and A. Watanabe [*J. Cell. Comp. Physiol.* **47**, 415 (1956)] have described a similar pattern of tymbal muscle activity in the Japanese cicada *Grapsopsaltaria nigrofuscata* and have recorded intracellularly from the tymbal motoneurons. With extracellular recording, they detected 200 per second activity in interneurons during the call, and proposed that the motoneurons respond alternately to a pacemaker neuron discharging at 200 per second, with a mutual inhibitory interaction ensuring alternation.
9. A. D. Blest, T. S. Collett, J. D. Pye [*Proc. Roy. Soc. Sec. B* **158**, 196 (1963)] have described a very similar mechanism in the arctiid moth *Melese laodamia* Druce. In this species the tymbal cavities are much smaller than in the cicada, and the sound produced is ultrasonic, in the range 30 to 90 khz. Each tymbal has 15 to 20 ribs, whose buckling excites the resonators at rates between 500 and 1200 per second. Sound bursts (contraction-relaxation cycles) are produced at an average rate of 2.4 per second; their function is believed to be to "jam" the echolocation mechanisms of the bats which prey on these moths.
10. The force transducer was mounted on a rod held in a fairly stiff ball joint (Grass Instrument Co. cortical electrode holder). By flicking the other end of the rod with a finger, a rapid smooth "twitch" of the appropriate amplitude could be made, with reasonably good control of the speed of motion.
11. S. M. Walker and K. H. Reid, in preparation.
12. I thank Dr. S. M. Walker for introducing me to this insect and suggesting this study, and Dr. E. Roseman for the loan of equipment.

4 February 1971; revised 1 April 1971

Residues of Total Mercury and Methylmercuric Salts in Lake Trout as a Function of Age

Abstract. *An analysis of the concentrations of total mercury and methylmercuric salts in lake trout of precisely known ages from 1 to 12 years has been carried out. The concentrations of both total mercury and methylmercury increased with the age of the fish. The proportion of methylmercury to total mercury also increased with age.*

There have been numerous reports of relatively high concentrations of mercury in fish (*1*). Although many analyses of fish for mercury have been carried out, it is usually difficult to relate concentrations to time of exposure since judging age by scale examination is very difficult, particularly in older fish. In a study of northern pike (*Esox lucius*) Johnels and Westermark (*2*) found the total mercury concentration proportional to the age of the fish but admitted the unreliability of judging their ages by scale examination. In the work reported here residues of mercury have been determined in lake trout of known age.

We were fortunate to have available lake trout (*Salvelinus namaycush*) from Cayuga Lake in Ithaca, New York, of known age since they are tagged and stocked there annually as fingerlings. It was not known what concentrations of mercury might be expected in the fish. Mercury reaching the lake could, however, result from its use in laboratory research, in dental and medical services, in agriculture, in coal burnt in power plants, and from other sources. In October 1970, fish were netted in order to obtain samples of as many different ages as possible. Without evisceration, each was mechanically chopped, ground, and thoroughly mixed. A 1-g

Table 1. Corrected* concentrations of total mercury and mercury as methylmercury in Cayuga Lake trout.

Fish code	Age (years)	Mercury (total) (ppm)	Methylmercury (calculated in terms of mercury) (ppm)	Percent of total mercury as methylmercury
95	1	0.24	0.074	30.8
99	1	.28	.098	35.0
101	1	.19	.066	34.7
59	2	.25	.108	43.2
78	2	.26	.096	36.9
89	2	.31	.121	39.0
80	3	.38	.208	54.7
82	3	.45	.271	60.2
112	3	.28	.157	56.1
104	4	.44	.375	85.2
105	4	.41	.288	70.2
151	4	.44	.346	78.6
155	5	.43	.349	81.2
10	6	.46	.412	89.6
11	6	.55	.479	87.1
13	6	.50	.445	89.0
2	7	.40	.283	70.8
4	7	.46	.403	87.6
5	7	.44	.349	79.3
1	8	.60	.534	89.0
6	8	.59	.519	88.0
8	8	.47	.479	101.9
19	9	.53	.433	81.7
3	11	.58	.407	70.2
15	12	.62	.415	66.9
16	12	.66	.503	76.2
22	12	.44	.389	88.4

* Corrected for percent recovery (see text).

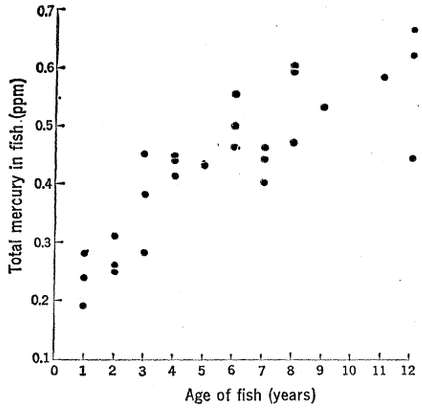

Fig. 1. Total mercury in Cayuga Lake trout as a function of age.

subsample was dried and ashed by Schoniger combustion (*3*). The total amount of mercury in the absorbing solution was determined by flameless atomic absorption spectrophotometry (*4*). This method is easily sensitive to 0.1 part per million (ppm) of mercury in fish. The accuracy of the method was checked by recovery studies in which mercury as mercuric chloride was added to the fish samples before drying, and the samples were then dried, combusted, and analyzed. The percent recoveries of 0.3 ppm of mercury added to four samples of lake trout of ages 1, 2, 3, and 5 years were, respectively, 77, 80, 93, and 83.

Figure 1 illustrates the relation between total mercury in lake trout and age. All mercury concentrations in Fig. 1 were corrected for the average percent recovery (83.25). The length of the fish varied from about 20 cm (for a 1-year-old fish) to about 76 cm (for a 12-year-old fish).

Residues of mercury in fish are often present largely as highly toxic methylmercuric salts (*5*). It was of interest therefore to determine the effect of age on the concentrations of this metabolite in the same fish samples. Westöö has reported a method for the extraction and isolation of methylmercury compounds from fish (*6*). In this method the sample is extracted with hydrochloric acid, the methylmercuric compounds are partitioned into benzene, the bonds linking mercury to sulfur are cleaved with mercuric chloride, the methylmercury is extracted as the hydroxide, and finally the mercury is reconverted to the chloride for gas chromatographic analysis. A microwave-powered helium plasma emission detector (*7*) was used to selectively monitor the emission line of atomic mercury at 2537 Å. The method is sensitive to 0.1 ppm of methylmercuric salts in fish. The percent recovery of 0.174 ppm of methylmercuric chloride added to one 2-year-old and three 3-year-old lake trout samples was, respectively, 56.3, 54.6, 56.3, and 54.6. Westöö found that there is approximately a 30 percent loss of methylmercuric salts in his procedure as a result of unfavorable partition coefficients.

Table 1 presents a list of concentrations of total mercury and methylmercury in fish by age and the percentage of total mercury that was present as methylmercury. The values for total mercury and methylmercury as listed are corrected for the average percent recoveries which were, respectively, 83.25 and 55.4. It is evident that the variation trend in the concentrations of methylmercuric salts with age in fish is, in general, the same as the variation trend of the total mercury with age, although the concentration of total mercury is consistently higher. This relation between total mercury (and methylmercuric salt concentration) and age may simply be a reflection of the time during which the fish have been exposed to their environment. It may also be significant that the total proportion of mercury as methylmercury appears to be smaller in the younger fish. Owing to the good reproducibility of analysis for both mercury and methylmercuric salts on several replicated fish samples, the higher total mercury concentrations may be significant and indicative of the presence of mercury in fish in a form or forms other than methylmercuric salts. Another possible metabolite is dimethylmercury, but there is at present no satisfactory method for the determination of this compound in fish. Concentrations of total mercury and methylmercury in the lake trout studied did not appear to be related to the sex of the fish.

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4. W. R. Hatch and W. L. Ott, *Anal. Chem.* **40**, 2085 (1968).
5. G. Westöö and M. Rydalv, *Var Foeda* **21**, 20 (1969).
6. G. Westöö, *Acta Chem. Scand.* **20**, 2131 (1966); *ibid.* **21**, 1790 (1967).
7. C. A. Bache and D. J. Lisk, *Anal. Chem.*, in press.
8. We thank W. D. Youngs for collecting the lake trout used in this study.

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Garfish Olfactory Nerve: Easily Accessible Source of Numerous Long, Homogeneous, Nonmyelinated Axons

Abstract. *The olfactory nerve of the garfish,* Lepisosteus, *is about 1 millimeter in diameter and about 20 centimeters long, depending on the size of the fish; it is easily prepared by breaking off successive scored segments of the rostrum. It consists of a relatively homogeneous population of about 10^7 nonmyelineated nerve fibers, each about 0.24 micrometer in diameter. In most other nerves each fiber is separated from all others by an enfolding Schwann cell, but in the olfactory nerve the fibers are directly in contact with one another in groups of several hundred fibers. The Schwann cell, not directly concerned with propagation of the nerve impulse, forms a thin layer at the periphery of the group and makes up a small proportion of the total cellular material. The volume of axon cytoplasm is about five times greater than that of Schwann cell cytoplasm, and the axon surface is about 30 times the Schwann cell surface. The ratio of surface to volume for axons of a typical olfactory nerve is about 5400 times that for the squid axon of the same diameter. The large proportion of axonal membrane recommends this nerve for use in chemical and physical studies of properties of axon membranes.*

The nerve impulse is an event related to the axon surface: the electrical characteristics of the nerve fiber membrane at that surface have been most satisfactorily described for various giant fibers as large as 1 mm and more in diameter (*1*). The squid giant axon is admirably suited for the study of the