A Guide to the Properties, Characteristics, and Uses of Some General Anaesthetics for Fish

Gordon R. Bell

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A GUIDE TO THE PROPERTIES, CHARACTERISTICS, AND USES OF SOME GENERAL ANAESTHETICS FOR FISH
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A guide to the properties, characteristics, and uses of some general anaesthetics for fish

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PREFACE

This second edition has been prepared to meet continuing demand for information on general anaesthetics used in fisheries research. Two additional anaesthetics are included and the information on the others has been updated in the fold-out chart at the back of the bulletin. For the convenience of readers, the numerous references have been annotated.
BACKGROUND INFORMATION

Agents, described as general anaesthetics, which reversibly depress the sensory centres of the brain to various degrees and which finally eliminate reflex action, are being used more and more widely in fisheries biology. General anaesthetics first depress the cortex (stage of analgesia), then the basal ganglia and cerebellum (stage of delirium or excitement), and then the spinal cord (stage of surgical anaesthesia). Excessive dosage or prolonged exposure leads to involvement of the medulla; paralysis of the vital respiratory and vasomotor centres is then the usual cause of death. All general anaesthetics act to varying degrees as central nervous system depressants. Information concerning the properties, characteristics, and uses of anaesthetics for fish is so widely scattered that it was desirable to assemble the essential data, as is done herein, to permit ready selection of the most appropriate anaesthetic for laboratory or field work.

The chart presented can serve only as a guide because the effects of anaesthetics are governed by numerous factors. The dosage-response data, given as fairly broad ranges, have a general use because a given dose of anaesthetic is likely to produce the same effect in a number of different species (McFarland, 1959, 1960). However, it is wise to test the dosage-response relationship on a few fish under the pertinent conditions before anaesthetizing larger numbers. The bibliography is not exhaustive and is intended to serve only as a guide to further literature, much of which has been reviewed by McFarland (1959, 1960). Personal observations are added without reference.

Hypothermia as an anaesthetic is not listed because it is a physical method, but mention must be made of its usefulness either alone or in combination with chemical anaesthetics for fish transportation (Ho and Vanstone, 1961; Rodman, 1963. See “General Bibliography”), handling (Sehdev et al., 1963. See “2-phenoxyethanol”), and injecting (Ho and Vanstone, 1961). Water temperatures can be lowered by adding either ice, dry ice in an isolating container, or by using mechanical refrigeration. Dry ice cooling might be accomplished by enclosing the solid in an aluminum container with gas venting ports to keep carbon dioxide from the water.

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Paper No. 12 concerning the physiology and behaviour of salmonid fishes, from the Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C.

Manuscript received for publication June 15, 1964; revised September 15, 1966.
Another physical method for inducing anaesthesia is electroshock but its use is probably limited to manipulations involving rapid handling.

The danger of carcinogenesis in man from the use of the anaesthetics urethan (Wood, 1956; Hueper, 1963, p. 981. See “General Bibliography”) and cresol (Hueper, 1963, p. 1003) has been an important factor in excluding them from the chart presented here. In general, from these and other examples it seems wise to avoid prolonged contact with any foreign substances.

It is hoped that the effectiveness of the available anaesthetics for fish will not discourage active testing and development either by “borrowing” from the large and rapidly expanding array of anaesthetics for humans or by modifying the structure of functional groups of the present anaesthetics. Research in anaesthesiology is leading to more precise control and selection of the type and level of anaesthesia, advances which should be exploited in fisheries biology. Current opinion among anaesthesiologists is that more surgical procedures should be performed at only the analgesic level of depression in conjunction with the use of a peripheral muscle relaxant such as meprobamate. The increasing desire and need to perform complex surgery on fish will require the development of more sophisticated techniques for long-term anaesthesia than are available, to ensure the survival of the specialist as well as the “patient.”

ANNOTATED BIBLIOGRAPHY

Carbon dioxide


Used CO₂ anaesthesia in order to handle fish in 1000-gal tank trucks.

Chloral hydrate


Similarities in mode of action and pharmacology of chloral hydrate, trichloroethanol, and tribromoethanol discussed.


A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.
Chloreteone


A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.


M.S. 222 judged superior to chloreteone because of easier handling and less respiratory inhibition.

Nelson, P. R. 1953. Use of three anesthetics on juvenile salmon and trout. Prog. Fish-Cult., 15: 74.

Most desirable concentration of M.S. 222, chlorobutanol, and urethan: 1:12,500, 1:2,000 and 1:190, respectively. Therapeutic ratios low, e.g. 1:10,000 M.S. 222 caused 100% mortality according to this brief report of Nelson's work.

Ether


An investigation into the mechanism of action of anaesthetics using ether, chloroform, halothane and methoxyflurane.


Found ether anaesthesia (0.5-1.5% v/v) decidedly advantageous in the marking of fingerling lake trout.


Juvenile and adult steelhead anaesthetized and relaxed by immersion for 45–90 sec in 1.5–2% (v/v) solutions.

Methylpentynol


Emphasis is placed on control of gaseous requirements and ammonia levels during transportation. Sedation of fish by methylpentynol, chloral hydrate, and tertiary amyl alcohol is discussed.

Use of the drug for human therapy is discussed.


A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.


Successful transportation might require pH control as well as anaesthesia. Effective pH control using tris-hydroxymethyl-aminomethane (“Tris” buffer).


A pharmacological investigation of methylpentynol as a hypnotic; used dogs, rats, and humans.


Basic reference on transportation. Recommend use of methylpentynol, tertiary amyl alcohol, and chloral hydrate for sedation.

M.S. 222


Immobilization of spermatozoa by M.S. 222 shown to cause low fertility of eggs.


Basic reference on use of this anaesthetic.


Anaesthetic caused bradycardia of intact fish but tachycardia found in some intact teleosts by other workers. Concentration of anaesthesia likely important factor.

A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.


Cold shock plus M.S. 222 caused high mortalities.


M.S. 222 judged superior to chloretone because of easier handling and less respiratory inhibition.


Synthesis and characterization of the compound described, in addition to some limited observations on its anaesthetic properties for cold-blooded animals.


Key reference to important new literature on M.S. 222, its toxicity, determination, and efficacy as an anaesthetic. One of six papers published as a unit.


M.S. 222 (1:10,000) caused, progressively, primary and secondary tachycardia and an auriculo-ventricular dissociation.

2-Phenoxyethanol


Dosage-response relationship of the anaesthetic studied at several temperatures and use described.
Propoxate


A general description of the compound, dosages required, and effects produced using goldfish. Also some data using frogs, salamanders, sunfish, rainbow trout, and Atlantic salmon.

Quinaldine


General description of the use and effects of quinaldine on warm freshwater fishes such as green sunfish. Later workers have used concentrated solutions to immobilize marine and freshwater specimens for field collection.

Sodium Amytal


A practical and comprehensive treatise on hatchery methods including the use of several anaesthetics.


A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.


Used sodium amytal (65mg/4 liters), bone charcoal and permutit to control levels of metabolic rate and wastes of fish transported in sealed, oxygen-charged plastic bags. Noted toxicity of anaesthetic to one species.

4-Styrylpyridine


A general description of the compound, its mammalian toxicity, dosages required, and effects produced using several species of lampreys and freshwater fish, including rainbow trout.
Tribromoethanol


Similarities in mode of action and pharmacology of tribromoethanol trichloroethanol, and chloral hydrate discussed.


A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.

Tertiary-amyl alcohol


A fundamental treatise on anaesthesia of fishes. Some physiological and behavioral effects of 15 anaesthetics were examined using Fundulus, Girella and Paralabrax.


Broad yet practical experiments and discussion involving common anaesthetics. Used same fish as in 1959 paper.

GENERAL BIBLIOGRAPHY


A concise and comprehensive encyclopedia of chemicals and drugs of interest to the chemist, pharmacist, physician, and members of allied professions. Also contains useful tables of physical, chemical, and mathematical data.


An outline of some principles and practices of anaesthesia.


Tested the efficacy of various tags and marks in conjunction with the use of the anaesthetics methylpentynol, M.S. 222. quinaldine, tertiary-
amyl alcohol, and the antibiotics terramycin (oxytetracycline) and penicillin. M.S. 222 found best. Antibiotics did not increase survival but may have reduced shedding of tags by 25%.

An investigation into the mechanism of action of anaesthetics using ether, chloroform, halothane, and methoxyflurane.

A textbook of pharmacology, toxicology, and therapeutics of fundamental importance. Several chapters on anaesthesia and anaesthetics, hypnotics and sedatives. Chapter 10 discusses chloral hydrate, trichloroethanol, chloretone, and methyl pentynol.

Used hypothermia (2-4 C) for effective anaesthesia prior to intramuscular injection of captive salmon.

A broad ecologic and pathologic survey of carcinogenic agents. Data suggest one should be very careful to avoid prolonged exposure to many chemicals, in addition to urethan.

A very useful, independently prepared guide to anaesthetics and anaesthesiology for fishes. Treatment of subject strikingly similar in approach to this Bulletin.

An extensive compilation of formulations and chemicals of pharmacological interest with discussion, where appropriate, of their physical and chemical properties, uses and hazards, physiological effects, and methods of assay.

Of several methods tested, author favoured use of dry ice as hypothermic agent for sedation of fish during air transport. Sedation by M.S. 222 at 1:40,000 gave promising results.

Some techniques for minor surgery, a convenient operating table, and associated anaesthetizing system are described in detail.


A concise, comprehensive tabulation of data of importance to general biologists.


Author inferred from animal work that urethan might be directly or indirectly carcinogenic to man and therefore should be abandoned as an anaesthetic or used with great care.
Recent Bulletins of the
Fisheries Research Board of Canada


No. 142. The chinook and coho salmon fisheries of British Columbia. By D. J. Milne. (1964. 46 p., $1.00.)

No. 143. Life history and present status of British Columbia herring stocks. By F. H. C. Taylor. (1964, 81 p., $1.75.)

No. 144. Smelt life history and fishery in the Miramichi River. New Brunswick. By R. A. McKenzie. (1964, 77 p., $2.00.)

No. 145. Scallops and the offshore fishery of the Maritimes. By N. Bourne. (1964, 60 p., $1.75.)

No. 146. Comparative feeding habits of the fur seals, sea lion and harbour seal on the British Columbia coast. By D. J. Spalding. (1964, 52 p., $1.50.)

No. 147. Lobster storage and shipment. By D. W. McLeese and D. G. Wilder. (1964, 69 p., $1.75.)


No. 151. Special products from freshwater fish. By A. W. Lantz. (1966, 45 p., $2.00.)


No. 154. Marine resources of Newfoundland By Wilfred Templeman. (1966, 170 p., $3.50.)

Notes

1. Solubility — the system and abbreviations commonly used in chemistry handbooks have been adopted. Where no exact values are available, i. indicates insoluble; v. sl. sol., very slightly soluble; sl. s., slightly soluble; s. sol., soluble; v. s., very soluble; and \( \infty \) indicates complete miscibility. Solubilities are given at 20°C unless another temperature is indicated by a superscript.

2. Volume — all gallons are British Imperial, i.e. 1.2 times US gallons. One litre = 0.26 US gal or 0.22 British gal.

3. Temperature — all temperatures are in degrees centigrade or Celsius (C) and can be converted to degrees Fahrenheit (F) thus:
   \[ \text{deg F} = \text{deg C} \times \frac{9}{5} + 32. \]

4. Concentration — 1 part per million (1 ppm) \( \equiv \) 1 mg/litre \( = 1:1,000,000. \)
   1 g/litre \( \equiv 1:1000 = 1000 \text{ ppm}. \)
   e.g. 80 ppm \( \equiv 80 \text{ mg/litre} \equiv 1:12,500. \)

5. Several sections are left blank because no data are available but these can be filled in when data appear.

6. Mention of trade names or manufacturers does not constitute endorsement of the product or firm by the Fisheries Research Board of Canada.
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