Clove oil: an ‘eco-friendly’ alternative to cyanide use in the live reef fish industry?

by Mark V. Erdmann

Introduction

As mentioned by Erdmann and Pet (this issue), an interesting new development in the aquarium fish trade in Indonesia is the reported use of clove oil as an ‘eco-friendly’ alternative to cyanide solution to stun and capture ornamental fishes in situ. While the accuracy of this claim obviously requires substantiation, this is certainly an interesting idea worthy of further investigation.

Clove oil, distilled from the crushed stems, buds and leaves of the clove tree Eugenia caryophyllata, has been used for centuries as a topical anaesthetic for humans in Indonesia (Soto & Burhanuddin, 1995). The primary active ingredient in clove oil is the phenolic compound eugenol, which commonly comprises 70–90 per cent of commercially sold clove oil in Indonesia (Hernani & Tangendjaja, 1988).

I first became aware of the use of clove oil as an anaesthetic for capturing marine organisms several months ago when a colleague suggested that I use a clove oil/ethanol solution to immobilise and capture stomatopod crustaceans in their cavities within the reef. This solution was extremely effective and greatly increased my capture success.

Several months later, when I encountered the report of clove oil used in the aquarium fish trade in Ambon, I tracked down the original reference from whence my colleague had suggested clove oil use (Munday & Wilson, 1997).

Subsequent discussions with Philip Munday and several aquaculture researchers from the University of Guelph (Cristina Soto, David Noakes and Richard Moccia) suggested that clove oil is a highly desirable, if underutilised, fish anaesthetic that may have a place in the live reef fish trade.

A superior fish anaesthetic?

Though clove oil (eugenol) has been used as a fish anaesthetic for at least the last quarter-century (Endo et al., 1972; Hikasa et al., 1986), it has recently been the focus of research aimed at establishing its effectiveness and safety as an anaesthetic for use in both aquaculture and in wild-capture and laboratory research on coral reef fishes (Soto & Burhanuddin, 1995; Munday & Wilson, 1997;...
Keene et al., 1998). Anaesthetics such as quinaldine and MS-222 are used widely by both aquaculturists and fish biologists for the purpose of minimising stress and injury during capturing, handling, sorting, and transporting wild-caught and cultured fishes (Munday & Wilson, 1997; Keene et al., 1998).

However, not only are these chemicals expensive and often difficult to obtain in developing countries, they may also have potential harmful side effects on humans—especially in the situation where the anaesthetic is squirted by a diver attempting to capture wild fishes (Munday & Wilson, 1997). Clove oil is both inexpensive and non-harmful to humans, making it attractive as a possible alternative anaesthetic.

While their techniques, dosages and target species differed widely, both Munday and Wilson (1997) and Keene et al. (1998) found clove oil to be on the whole a superior anaesthetic compared to a number of other chemicals, including MS-222, quinaldine, and benzocaine.

Without attempting a thorough review of those studies, their results suggested that clove oil was an excellent alternative for the following reasons:

1) Clove oil is highly effective even at low doses. Keene et al. (1998) report that it induced anaesthesia faster and at lower concentrations than MS-222, while Munday and Wilson (1997) found clove oil only marginally less effective than quinaldine and more effective than 3 other chemicals, except at high doses.

2) Clove oil provides a much calmer induction to anaesthesia than the other chemicals.

3) Recovery time after clove oil anaesthesia is substantially longer than recovery time from other anaesthetics.

4) Clove oil is much less expensive than other chemicals. For example, Keene et al. (1998) showed clove oil to be less than 1/15 the price of MS-222 when preparing solutions of each capable of inducing stage 5 anaesthesia in less than 3 minutes in rainbow trout. Both of these studies found that dissolving clove oil in ethanol first was preferable, as this kept the clove oil evenly suspended in solution and induced anaesthesia more quickly.

The two groups use very different concentrations: Keene et al. (1998) suggest a concentration of 40–60 ppm, dissolving the clove oil first in a small amount of ethanol and then diluting with water; while Munday (pers. comm.) uses 100 ml clove oil dissolved in 400 ml of ethanol only (250 ppt). The large difference is easily accounted for as a difference in requirements; Keene et al. (1998) used clove oil as an anaesthetic for cultured juvenile trout, while Munday uses the stronger solution to capture small reef fishes in situ. In the latter case, a much higher concentration is required in order to counter the effects of instant dilution upon squirting the solution into the ocean and to achieve a faster induction to anaesthesia.

Possible uses in the live reef fish trade

All of the above mentioned researchers are highly enthusiastic about clove oil’s potential as a fish anaesthetic. I can imagine at least three possible uses for clove oil within the live reef fish trade, especially as it is practised in developing countries such as Indonesia.

1) Anaesthetic for wild capture

While the use of cyanide to capture live reef food fish seems to be declining in Indonesia, it is still very widespread, and is still used in the majority of ornamental fish capture operations observed. While organisations such as the International Marinelife Alliance and the Haribon Foundation have done important work to promote a ‘drug-free’ tradition for aquarium fishers in particular, I believe that any chemical which can be shown to be otherwise reef-friendly should be considered for promotion in the live reef fish trade as a cyanide replacement.

The fact remains that some highly sought-after ornamental and food fish are difficult to target with barrier nets or hook and line, and more to the point, many of the fishermen are not concerned if corals are killed or the collected fish die later in an aquarium or cage—they have already been paid. Given these considerations, I believe it would be worthwhile to further investigate the potential for clove oil as a replacement for cyanide in wild capture of live reef fish.

In order to receive widespread support from both fishermen and environmentalists for clove oil use in the capture of reef fish, at least two conditions must be met.

First, clove oil solution must be shown to be as effective as cyanide in stunning reef fishes. Clove oil compares highly favourably to other (legal) fish anaesthetics, but cyanide was not included in the above mentioned test comparisons for obvious reasons! Munday (pers. comm.) has found clove oil to be highly effective in capture of damselfishes on the Great Barrier Reef. Munday and Wilson (1997) make the point that the ability of
clove oil to induce anaesthesia even at low doses is extremely valuable for use in the field, where instant dilution is a major problem.

I have personally used clove oil in ethanol solution to collect stomatopod crustaceans from cavities in live and dead coralline algae, and found it extremely effective. I can only imagine it would have a similar efficacy on spiny lobster (Panulirus spp.), which are currently collected by using cyanide solution in Indonesia. Whether clove oil would be an effective anaesthetic for larger grouper or Napoleon wrasse for the live reef food fish trade is unknown; however, I believe this would be a worthy avenue of research.

Secondly, clove oil solution must be shown to be harmless to non-target reef organisms (including corals) in the concentrations which would be used to stun reef fishes. My initial experience with clove oil/ethanol solution showed that coralline algae would frequently bleach soon after contact with my solution, though it invariably recovered within a week’s time. Munday (pers. comm.) and Soto (pers. comm.) suggested this might be more a result of the ethanol than the clove oil. Further anecdotal experiments of squirting clove oil and water solution on Pocillopora spp. and Acropora spp. coral colonies in situ showed no observable ill effects.

Obviously, before clove oil can be promoted for widespread use, it would need to be tested thoroughly for its effects (both with and without ethanol) on corals and other invertebrates, preferably in both the field and in a laboratory setting. The rigorous experiments of Jones (1997) on cyanide effects on corals in the laboratory could serve as a template for clove oil tests.

Even if these two conditions are met, there is one further consideration which may negate any potential advantages of clove oil. In the standard scenario of divers using cyanide to capture live reef food fish, the diver chases the fish into a hole, squirts enough cyanide solution into the hole to stun the fish, and then proceeds to break away all of the surrounding coral in order to access the stunned fish. Under such a scenario, the fact that the chemical used is benign is irrelevant; the main damage to the reef is caused by the diver breaking away the coral (Pet, pers. comm.).

My personal view is that the extent to which this coral breakage happens is exaggerated; in the several cyanide fishing episodes I have witnessed underwater, the fish invariably fled from the hole after being squirted with cyanide, soon thereafter losing its balance, and was easily collected. This is an important consideration, but one which is less applicable to the collection of ornamental fish, where the potential for extensive collateral environmental damage from cyanide use is actually much greater than in the live reef food fish trade (Erdmann & Pet-Soede, 1996).

2) Anaesthetic for handling

Wild-caught grouper and Napoleon wrasse often receive rough handling at the collection cages in Indonesia, where they may be stored for up to several months before transport to importing countries like Hong Kong.

In my experience in Indonesia, when these fish are sorted or moved between cages, they are typically given either no anaesthesia or, worse still, may be hit with another dose of cyanide to ‘calm’ them. Surely it would not be difficult to adapt the clove oil dosages reported by Keene et al. (1998) for handling rainbow trout to those required for coral trout, Napoleon wrasse, and even ornamental fishes.

Clove oil use during handling could significantly reduce cage mortality of live reef fish (still a problem in Indonesia), and is much cheaper than alternatives such as MS-222. The latter point should make clove oil attractive even to live fish dealers in countries like Australia where anaesthetic use is common.

3) Anaesthetic for transport

This is perhaps the most important area where clove oil promotion could have positive effects in a country like Indonesia. Even here, anaesthesia is commonly used in transport of live reef fish. Unfortunately, this presents the largest loophole in efforts to prevent cyanide fishing in Indonesia; cyanide is considered legal for use as an anaesthetic for fish transport. This makes it nearly impossible to prosecute vessels with cyanide on board or even those with cyanide-tainted fish; the fishermen can always claim that the cyanide was used as an anaesthetic for transporting the fish, which were otherwise captured legally. It is only illegal to actually capture the fish with cyanide, and this is exceedingly difficult to prove.

While I have not seen an official explanation of why cyanide is legal as a transport anaesthetic, one can easily imagine the economic arguments that would be used by politicians. Cyanide is relatively cheap and readily available, and it would not be fair to require poor fishermen to purchase expensive imported chemicals such as quinaldine or MS-222. However, at roughly Rp 6000 (US$ 0.60) per 100 ml bottle, clove oil surely compares with cyanide for cost effectiveness.
Furthermore, in Indonesia, clove oil is a local product, an important political consideration in promoting its use.

If policy-makers in Indonesia could be persuaded that clove oil is an effective, inexpensive and benign substitute for cyanide as a transport anaesthetic, it should be possible to ban the use of cyanide outright, thereby closing the gaping legal loophole that now exists. This, I believe, is the strongest argument for the promotion of clove oil use in the live reef fish trade in Indonesia.

**Conclusion**

Recent research has shown that clove oil is a highly effective, cost-efficient and safe fish anaesthetic for use in aquaculture and laboratory research settings. Further research must be conducted in order to verify the ‘eco-friendliness’ of clove oil for use in wild capture of reef fishes, but its potential to replace cyanide use in the live reef fish industry seems promising. I urge those involved or concerned with the live reef fish trade to consider this potential and openly debate its merits and drawbacks.

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**References**


**Further readings on clove oil:**
