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Effect of Ixtoc I Crude Oil and Corexit 9527 Dispersant on Spot (*Leiostomus xanthurus*) Egg Mortality

G. J. Slade

Duke University, Durham, NC 27706

An oil spill dispersent prevents the formation of an oil and water emulsion, removes the fire hazard of an oil spill, inhibits the contamination of shorelines, and facilitates the evaporation, biodegradation, and solubilization of the oil (LINDBLOM 1978). Although advocates of dispersant application believe that chemical dispersion serves to accelerate the natural process of oil dispersion in a form that is safer ecologically than naturally formed tarballs and mousse, TRUNDEL (1978) pointed out that this treatment might present hazards to the marine community within the water column. He hypothesized that the oil-dispersant mixture may be more toxic than the naturally dispersed oil alone and that the chemical dispersion may force more oil into the water at a faster rate than would naturally occur. Studies on algae, clams, oysters, and fish larvae have shown that suspensions of oil and dispersant are more toxic than oil alone (HIDU 1965, KUHNHOLD 1970, TRACY et al. 1969, WILSON 1970).

Concern arose over the effect that chemically dispersed crude oil might have on the marine organisms in the western Gulf of Mexico during the summer and fall of 1979, when Corexit 9527 was purchased by the Mexican government for application over a 180 x 80-km oil slick originating from the ruptured Ixtoc I well located in the Bay of Campeche, 20 miles off the Mexican coast. Many species of fish in the Gulf of Mexico spawn during summer and fall (Table 1). A significant perturbation during this critical period could seriously reduce the contribution of that age class (DAHLBERG 1979).

In this study I compare the effects of Ixtoc I crude and Corexit 9527 on the egg mortality of a fish species occurring in the Gulf of Mexico. Although the species used in this study - spot, Leiostomus xanthurus, is not important as a commercial food fish in the gulf, their early life history is similar to other more significant gulf sciaenids, e.g., Micropogonias undulatus and Sciaenops ocellata. L. xanthurus spawn during the fall and early winter in nearshore ocean waters and produce floating eggs, 0.8 mm in diameter, which hatch in 48 h at 20°C (POWELL & GORDY 1980).

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Table 1. Commercially valuable fishes in the Gulf of Mexico which produce pelagic eggs that could have been affected by the Ixtoc I spill.

Species	Spawning Time	Spawning Location
Brevoortia patronus (gulf menhaden)	fall/winter	northern gulf, 10-100 km offshore
Lutjanus campechanus (red snapper)	summer/fall	west Florida, Campeche Banks, up to 1200 km offshore
Micropogonias undulatus (Atlantic croaker)	summer/fall	northern gulf, up to 80 km offshore
Sciaenops ocellata (red drum)	fall/winter	northern gulf, nearshore
Scomberomorous cavalla (king mackerel)	summer	throughout gulf

MATERIALS AND METHODS

Eggs: Eggs used in these experiments came from nine hormonally-induced laboratory spawnings of spot, L. xanthurus, during February and March, 1981, at the Beaufort Laboratory, following the methods of HETTLER & POWELL (1981). Three to six female L. xanthurus were used in each spawning. Eggs were individually selected using a 10X microscope so that only developing, viable eggs were used. Each replicate in the experiments consisted of 100 early blastaula eggs, 2-6 h old, except for the final series of experiments which used eggs up to 24 h old. For each test in each of four series of experiments, three replicas were used. Each replica was conducted in a 10.2-cm diameter glass culture bowl with 200 mL of 30 parts per thousand salinity sea water at 20°C with a 12L:12D photoperiod. Eggs were incubated until hatching or 48 h and then the number of hatched or still living eggs were counted.

Crude oil and dispersant. Ixtoc I crude from the same source as used by RABALAIS et al. (1981) was used to prepare a fresh stock of oil accomodated sea water (OAS) before each experiment following a modification of TRUNDEL's (1978) technique: 0.5 mL of crude was added to 200 mL sea water in a 250-mL separatory funnel, agitated by hand for 5 min, and allowed to settle for 30 min. Approximately 175 mL of the stock OAS was drawn off and then diluted.

Corexit 9527 was added at various concentrations to sea water or OAS based on the surface area of the culture bowls containing eggs.

The dispersant was applied at 2.5 to 200 ppm to the surface with a medicine dropper and agitated gently to ensure mixing.

Experiments: Preliminary experiments determined the LC_{20}, a level of OAS dilution which caused a mortality 20% greater than the controls, but permitted sufficient survival so that the effect of the dispersant, if any could be observed. When OAS was added in various concentrations, mortality increased as a function of increases in OAS. An LC_{20} was established at the dilution of 1 part stock OAS diluted with 2.5 parts sea water. This concentration was used for all experiments. Experiments were conducted to (1) determine the effect of the dispersant at various concentrations when added either to sea water alone or the LC_{20} OAS, (2) compare the effect of LC_{20} OAS/Corexit (20 ppm) together, and (3) test eggs from time of fertilization to 24 h after fertilization to exposure to a combination of LC_{20} OAS and Corexit (20 ppm), and to LC_{20} OAS alone. The egg stages in the last experiments included blastula, gastrula, and early embryo.

RESULTS

An increasing concentration of dispersant added to either sea water alone or LC_{20} OAS caused egg mortality to increase (Table 2).

Table 2. Percent L. xanthurus egg mortality at various concentrations of Corexit 9527 in the presence and absence of LC_{20} OAS. The concentration was converted to equivalent gal/acre for comparison. Percent mortality is average of three replicates, 100 eggs each.

Concentration (ppm)	Concentration (U.S. gal/acre)	Corexit + sea water % Mortality	± 1 S.E.	Corexit + OAS % Mortality	± 1 S.E.
0	0	13.6	1.8	15.0	4.3
2.5	0.06	-		20.0	2.9
5.0	0.12	13.3	1.4	17.6	3.7
10.0	0.25	21.6	1.3	24.3	0.7
20.0	0.50	22.0	7.1	41.6	6.4
40.0	1.00	33.3	6.5	75.6	6.4
100.0	2.50	80.3	19.6	100.0	0
200.0	5.00	100.0	0	100.0	0

Mortality increased as a linear function of dispersant concentration in sea water alone from 5 to 40 ppm: percent mortality = 13.21 + 0.51 (ppm), r^2=0.57. Increasing concentrations of dispersant added to OAS also increased mortality, but had a slope three times greater: percent mortality = 11.65 + 1.55 (ppm), r^2=0.91. From the linear regression, the LC_{50} for dispersant in LC_{20} OAS was determined to be 25 ppm.

To compare the effect of LC_{20} OAS alone, dispersant at 20 ppm alone, and both contaminants combined, data were separated in experiments where controls had low or high mortality rates on the assumption that low or high mortality in the controls and their related egg groups exposed to oil and dispersant was a function of the quality of eggs produced from a given female and/or environmental conditions at the time of spawning. The OAS/Corexit suspensions were more toxic to eggs than either contaminant alone (Table 3). There is an indication that this increase in toxicity is a result of an additive effect as seen when low and high mortality rates are pooled.

OAS/Corexit treated eggs had a net mean mortality above the control losses of 35% (low mortality control) and 53% (high mortality control).

Table 3. Percent mortality as a function of LC_{20} OAS alone, Corexit 9527 alone (at 20 ppm), and OAS/Corexit suspensions for low vs. high control mortality groups.

Treatment	Controls Low Mortality %	Controls High Mortality %	Pooled Controls (± 1 S.E.) %
Control (sea water)	12.5	41.7	27.7 ± 9.21
OAS (LC_{20})	32.0	57.7	51.2 ± 5.82
Corexit (20 ppm)	29.0	64.6	50.7 ± 4.75
OAS/Corexit	47.2	94.6	74.3 ± 5.39

Mortality decreased as a function of the egg stage during which the combination of OAS/Corexit was applied (Fig. 1). There was a reduction in the toxicity of the OAS/Corexit suspension between 8 and 14 h after fertilization to a level of mortality not statistically different from the control mortality ($F=0.135$). This mortality decrease between 8 and 14 h of development was: $y=138 - 6.9(x)$; $r^2=0.91$.

When OAS was applied to eggs without Corexit at various times after fertilization, mortality did not decrease until 16 h after fertilization and then it decreased, $y=74.6-1.35(x)$, $r^2=0.43$, until 24 h after fertilization at which point there was no statistically significant difference in mortality between OAS-treated eggs and control eggs ($P < 0.05$, T-test).

DISCUSSION

This study shows that untreated Ixtoc crude, at a dilution of 1 part oil accomodated seawater to 2.5 parts sea water, is less toxic to *L. xanthurus* eggs than crude dispersed chemically by Corexit 9527 applied at concentrations greater than 20 ppm. This level is equal to 0.5 U.S. gal/acre, but application of these

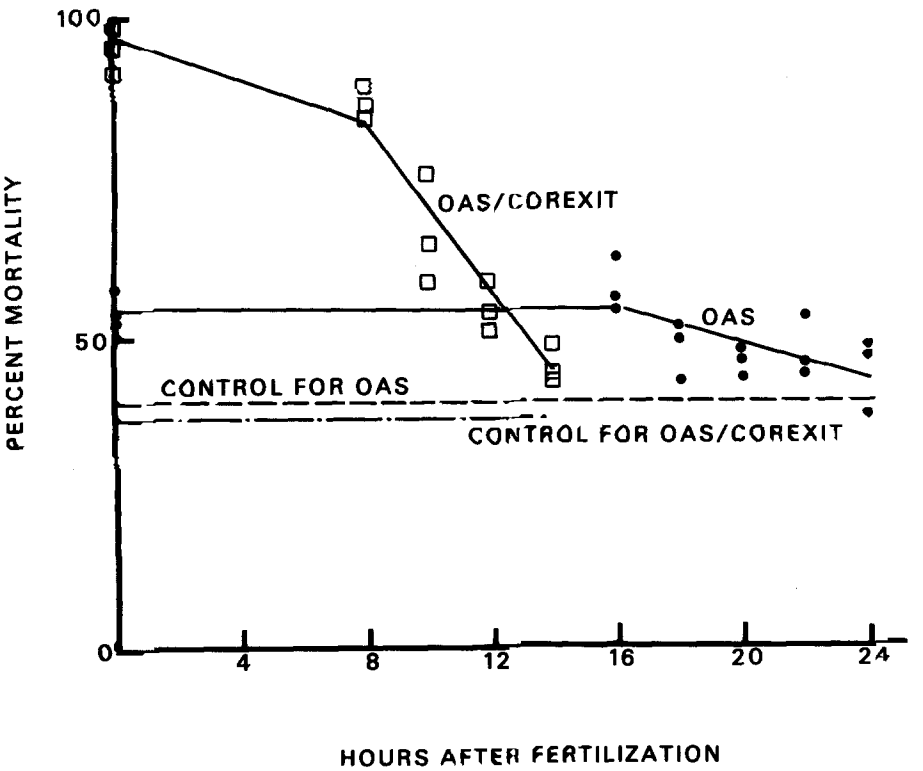

Fig. 1: L. xanthurus eggs were exposed to either OAS alone (solid circles) or OAS/Corexit (open squares) at various times during early development in Series III. Eggs showed initial high mortality when exposed to OAS/Corexit early in development. Each graph point represents time when a 100-egg group was exposed to treatment.

results as field guidelines should be treated with caution as these experiments did not simulate ocean-oil spill conditions with respect to factors such as depth of the water column, surface agitation, and solar radiation.

Temporal variation in the application of the chemicals indicated that mortality is relative to the stage of development with the earlier stages being more sensitive. Although in the practical application to oil spills, concern over the timing of the addition of dispersent to the spill is probably irrelevant due to the short development time of most fish eggs which are pelagic, inference about the mechanisms of toxicity may be made from the observation. In this study, mortality was greatest in the early stages through gastrulation when eggs were exposed to OAS/Corexit. Similar results were shown by STOSS & HAINES (1979) who

saw a decline in acute toxicity of toluene to medaka eggs during gastrulation and at the initiation of embryogenesis. The increased sensitivity of fish eggs during early development has been correlated with the high susceptibility of the chromosomes during the early stages of cell division to external pollutants. Oil and dispersents have been shown to cause abnormalities in chromosome division (ANDERSON et al. 1977). About 20% of the cod eggs and 46% of the pollack eggs exposed to the oil released from the Argo Merchant oil spill were dead or dying with their chromosome division arrested (ANNON. 1979). RABALAIS et al. (1981) added Ixtoc I oil accommodated water to red drum eggs 1 h before mean hatching time and noted that more than one-half of the living larvae had skeletal anomalies. From these and other reported non-lethal effects on normal development following exposure to external pollutants, further studies on the effect of oil and dispersants on growth and survival of fish larvae from treated eggs are required before better assessment of the impact of oil spill treatment by dispersants can be made.

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