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ABSTRACT: A new device for orally delivering substances to coyotes (Canis latrans) has been under development for approximately 10 years. The development of the coyote lure operative device (CLOD) is described along with some recent field evaluations of the CLOD system. In general, the results of these field tests indicate that the CLOD shows potential and merits further development.

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INTRODUCTION

Coyote damage problems seem resistant to solution to everyone's satisfaction. Successful management of coyote damage problems necessitates a variety of techniques for reducing damage and requires flexibility in their application to individual situations. However, legal and other restrictions often reduce the options available to personnel responsible for reducing damage. Thus, there is a continuing need for additional techniques and strategies for controlling coyote damage. This paper describes the development of a new device that has potential for orally delivering substances to free-ranging coyotes and summarizes some recent field tests of this device.

DEVELOPMENT OF CLOD CONCEPT

The coyote lure operative device, or CLOD, was developed to capitalize on results from research to improve coyote lures. This coyote lure research was initiated in 1972 and was continued as a collaborative project between Dr. Walter E. Howard and his associates and students at the University of California, Davis, and Dr. Roy Teranishi and his associates at the U.S.D.A. Western Regional Research Center, Albany, California. Efforts to improve lures were made by systematically identifying odorous chemicals to which coyotes were strongly attracted. During these research efforts, licking-chewing responses by captive coyotes exposed to chemicals such as oleic acid were observed and studied by Timm (pers. comm.) at the University of California (UC) Hopland Field Station and the volatiles steam-distilled from oleic acid also evoked licking and chewing (Teranishi et al. 1981a). Coyotes did not direct their licking-chewing responses to the test apparatus as if to taste the chemical. Instead, it appeared that the odor characteristics elicited these behavioral responses. This response to olfactory stimuli without being directed to an object appeared to closely resemble the flehmen response exhibited by male lions (Panthera leo) in response to estrous urine from female lions (Schaller 1972). However, the function of the vomeronasal organ (the organ usually involved in flehmen responses by mammals) in coyotes is unknown and some investigators believe it to be vestigial and inoperative (Lehner 1978).

The Howard-Teranishi research team described additional coyote behavioral responses to selected odors, suggesting that the ability of specific odors to elicit a greater frequency of specific behaviors might have potential application in coyote damage control (Fagre et al. 1981) . Several odors, such as trimethylammonium valerate (TMAV), reliably elicited biting responses by captive coyotes at the UC Hopland Field Station. To increase the frequency and duration of these biting responses, Fagre et al. (1981) tested coyotes for responsiveness to a variety of substances with different tastes, such as proline (a flavor enhancer for dogfoods). Captive coyotes proved to have the most frequent and vigorous responses to the sweet flavor in the form of sucrose, biting at the test apparatus while consuming the sucrose (Fagre et al. 1981). Sucrose, when presented with TMAV, increased biting responses over 3 times the level evident with TMAV alone.

Concurrently, the presentation of the odor and taste stimuli to coyotes was changed from ground-level to approximately 60 cm (or coyote eye-level) above the ground on "baitposts" (Teranishi et al. 1981b). The idea was 1) to discourage coyote rubbing and rolling behavior in response to odors encountered on the ground, and 2) to direct the coyotes' attention to a biteable object which was the source of the odor and taste stimuli. When captive coyotes visited these baitposts, the biting responses to specific odors were increased as much as 14 times as compared to biting responses when presented at ground-level (Fagre et al. 1981). However, further research with captive coyotes at the UC Davis campus indicated that the frequency of approaching objects on the ground was higher than for those raised off the ground. This baitpost idea was developed by R. Teranishi and W. E. Howard in conjunction with Donald Balser of the Denver Wildlife Research Center, U.S. Fish and Wildlife Service in 1979-1980. Earlier field research by this organization to ascertain the effectiveness of the M-

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44 device when placed in tree trunks also demonstrated that coyotes will readily bite some odorous objects raised above ground level (Robinson 1942). Limited field tests at the UC Hopland Field Station indicated that free-ranging coyotes could be attracted to baitposts baited with various attractants, including TMAV (Murphy et al. 1979). A U.S. patent for the baitpost concept was registered to R. Teranishi and W. E. Howard in 1984.

At this point in the chronology of the development of a delivery device, which was later termed the CLOD, biting responses by captive coyotes could be consistently elicited when baitposts treated with specific odors were presented during tests and vigorous chewing and other consumptive behaviors could be elicited if the baitposts were treated with sucrose syrup (Fagre et al. 1981). Further research on odor-related behaviors of coyotes indicated that trimethylammonium decanoate (TMAD) was more attractive, relative to other tested odors, and was most effective at eliciting biting responses (Fagre et al. 1983).

DEVELOPMENT OF CLOD PROTOTYPES

To better utilize the response of coyotes to sweet flavors, Rex E. Marsh, W. E. Howard, and their graduate students enclosed 10-cc amounts of sweet corn syrup in thin plastic packets (Butler et al. 1980, 1981). Once punctured by a coyote, the packet released the viscous syrup slowly enough to allow coyotes to consume it. The 10-cc amount of syrup also provided a sufficient quantity of carrier into which an active ingredient could be dissolved or suspended. As suggested by Marsh et al. (1982), potential active ingredients include biological markers, toxicants, reproductive inhibitors, or vaccines. The biological marker, Rhodamine B dye, was used in these syrup packets in some field tests to confirm that free-ranging coyotes were ingesting the syrup. The plastic packet containing syrup was enclosed within a pouch made of plastic lawn chair webbing material (Butler et al. 1980, 1981). This pouch had 2 purposes. First, it provided a durable exterior which could be fastened firmly to objects such as trees or fenceposts. Second, it required coyotes attracted to the pouch to bite it, breaking the syrup packet inside. Once the syrup was released, coyotes responded by ingesting the syrup readily. The vigor of coyote responses was great enough that the lawn chair webbing material was sometimes consumed along with the syrup.

Initial field tests with these webbing pouches at the UC Hopland Field Station proved disappointing. The pouches nailed to trees and wooden fenceposts were not visited often by coyotes. Reducing the amount of TMAD used from 1.0 cc/pouch to 0.5 cc/pouch improved coyote visitation, possibly because the strong odor stimulus of TMAD at 1.0 cc/pouch was repellent. Additionally, enclosing the webbing pouch within a second pouch made of rabbit pelts appeared to reduce neophobic responses by coyotes to the nylon webbing material. Howard, Marsh, and S. M. McKenna also tested these rabbit-pelt pouches in central California and McKenna et al. (1981) reported increases in coyote response when they were used. However, the biggest increase in coyote visitation to pouches came as a result of anchoring these pouches to the ground with long stakes (McKenna et al. 1981). Also, pen tests with a large sample of coyotes at the UC Davis campus had indicated that overall inhibition to approach and puncture pouches was least at ground level (Butler et al. 1980). Captive coyotes either failed to locate pouches at twice their eye-level height or appeared suspicious of them. Thereafter, all experimentation with both captive and free-ranging coyotes was conducted with pouches and prototype devices at ground level. The responses of domestic livestock to these pouches were examined by Howard and Marsh to determine the level of hazard to these animals if toxicants were used in the pouches. During 16 hours of observation, cattle and sheep showed little interest in pouches placed in their housing pens at the UC Davis campus (K. A. Hill, unpubl. rept.). After 24-hour periods of exposure, spaced several days apart, no damage to pouches was recorded in the pens of either species. Webbing pouches inside rabbit-pelt pouches were tested at the UC Hopland Field Station in 1981 (Fagre et al. 1983). Scent stations were established at 0.16-km intervals along ranch roads and fire breaks. After 1,076 station-nights, few of the pouches were punctured and coyote visitation rates were low, possibly because of a low density of coyotes in the area. However, an important observation was the extensive damage to webbing and rabbit-pelt pouches caused by rodents, which indicated a new device design was needed (Barnum et al. 1982).

DESIGN OF THE CLOD

In October 1981, a meeting between the staff of the California Animal Damage Control (ADC) program and research scientists from the University of California, Davis, and the U.S.D.A. Western Regional Research Center was held to discuss results of odor research. ADC District Supervisor Lewis introduced an idea he had developed for use in coyote trapping. A veterinary bandaging material (Vetrap) was tightly wrapped around a marshmallow so as to leave a long tail of the bandaging material for fastening to a trap jaw. This wrapped marshmallow was weatherproof and durable, but punctured easily by coyotes. The sweet taste of the marshmallow usually led to complete consumption of the Vetrap and marshmallow. Combining this idea with the pouch configurations previously used, a Bait Delivery Unit (BDU) was devised (Barnum and Fagre, unpubl. rept.) with syrup packets substituted for the marshmallow and a system developed for anchoring the BDU to the ground. W-U lure was effectively absorbed by the Vetrap to attract coyotes to the BDUs and elicit biting. In pen tests, the BDUs proved to be effective at attracting coyotes and the BDUs were also resistant to rupture, even though coyotes rubbed and rolled on top of them. Virtually all BDUs were bitten and consumed in pen tests (Barnum and Fagre, unpubl. data). McKenna-Kruse and Marsh (1982) found 72% of the BDUs visited in 1 test and 93% of those visited in another test were punctured and the con-

tents ingested.

There was, however, concern over the vulnerability of BDUs to nontarget animals due to rupturing of the syrup packet by livestock. McKenna-Kruse and Marsh (1982) found also that coyotes learned to unravel the Vetrap and steal the enclosed syrup packet without breaking it and this would present an unwanted risk should the packet contain a toxicant. To address these safety and selectivity concerns, Marsh, McKenna-Kruse and Howard in 1981 devised a spool-shaped acrylic resin core around which a syrup packet was wrapped (Marsh et al. 1982). This was tightly wrapped with Vetrap. The core prevented the syrup packet from being crushed and the syrup released. The wide spool top was designed to prevent small carnivores from inserting the device into their mouths. The entire device was coated with black-colored wax to make it less noticeable to curious people in the field. The problem of anchoring the device to the ground was solved by drilling and tapping the acrylic core so that it could be screwed onto a threaded rod protruding 4-5 cm above ground. This threaded rod was welded to a 30-cm piece of angle iron driven into the ground and, in initial tests, effectively prevented coyotes from moving the devices. Since a lure was essential for both attracting the coyote to the device and eliciting biting, Marsh coined the term "coyote lure operative device", and the acronym CLOD has prevailed. Marsh et al. (1982) first described this modified new device, its construction, and use in detail. W-U lure was developed as a synthetic coyote attractant during the same time as the CLOD was developed and became the lure subsequently used for CLOD research (Fagre et al. 1983). TMAD is the major ingredient to W-U lure, thus W-U lure also elicits the tendency to bite from coyotes.

HELD TESTS OF CLOD DESIGNS

California

Field tests of both BDUs and CLODs were conducted concurrently with pen tests and laboratory development by Howard, Marsh, and Teranishi and their associates. Barnum et al. (1982) found that BDUs were slightly more effective than CLODs in delivering syrup to coyotes in 64-ha (160-acre) pens at the U. S. Sheep Experiment Station, Dubois, Idaho. However, further testing of BDUs ceased because of the safety and selectivity concerns previously cited. These field tests were continued using only CLODs (J. S. Green, pers. comm.) and established that CLODs were capable of consistent delivery of syrup to coyotes.

In California, McKenna-Kruse and Marsh (1982) and Howard and Marsh (1983) tested a series of CLOD designs in the Sacramento valley and foothills of the Sierra Nevada. In general, there was little coyote response to the CLODs, probably due mostly to the low densities of coyotes in the test area. Only 2 CLODs were punctured during 620 station-nights and 8 months of testing. Both Howard and Marsh thought the CLOD could be improved upon and modifications were undertaken by graduate student R. H. Schmidt at the University of California-Davis in 1984. In the new design, the spool top was eliminated and a plastic vial was inserted over the stem (Fig. 1). This vial, rather than the packet, now contained the syrup. The syrup was made more viscous by mixing powdered sugar with the corn syrup (1:19 by weight). The entire device was sealed with a black plastic layer which was more durable than the previously used black-colored wax coating.

Howard, Marsh, and Tobin made field tests of the new design in California in 1984 but, after 3,602 station-nights, recorded only 21 CLODs damaged by coyotes or dogs.

Field tests at the UC Hopland Field Station in the coastal mountain ranges of northern California were also severely hampered by very low rates of coyote visitation and few conclusions were drawn from these efforts (Fagre and Howard, unpubl. data). Tests using captive coyotes at the UC Davis campus demonstrated that CLODs could successfully deliver toxicants to coyotes (Howard and Marsh, unpubl. data).

New Mexico

In a recent study by H. W. Stolzenburg and V. W. Howard, 90 scent-stations with CLODs were exposed to 2 coyote populations at bimonthly intervals. After 1 year, there were 5,400 station-nights recorded and a mean coyote visitation rate to scent-stations of 4.4% (Stolzenburg 1986). Of the coyotes attracted to the CLODs, 64% bit CLODs and 55% ingested the syrup contents. Stolzenburg (1986) concluded that CLODs were a relatively inexpensive and selective method for delivering oral substances to free-ranging coyotes.

Texas

Further development continued and extensive field evaluation of CLODs was undertaken at Texas A&M University from 1983 to the present in a series of field tests. Field evaluations of CLODs prior to the Texas tests lacked coyote visitation rates sufficient to discriminate between various CLOD designs. Coyote densities in south Texas are typically higher than those reported from any other region (Andelt 1985, Knowlton et al. 1986) and provide the opportunity for more efficient evaluations of CLODs.

Ebbert and Fagre (1988) recently reported results of several field evaluations designed to compare the effectiveness of the CLOD and the M-44. In the first study, the responses of coyotes to CLODs were compared to coyote responses to M-44s with 2 different odor attractants used to bait the devices. These attractants were the synthetic W-U lure developed concurrently with the CLOD and Mast's #6, a fetid bait commonly used with M-44s. The responses of coyotes on 2 different ranches were tested; 1 ranch had no coyote control program and the other ranch had a coyote control program which included trapping, snaring, aerial gunning, the use of M-44s, and a policy of shooting coyotes when sighted. A modified scent-station survey method was used to determine rates of coyote visitation and behavioral responses. No toxicants were used in these tests. Instead of a sodium cyanide capsule, a rubber stopper was inserted in

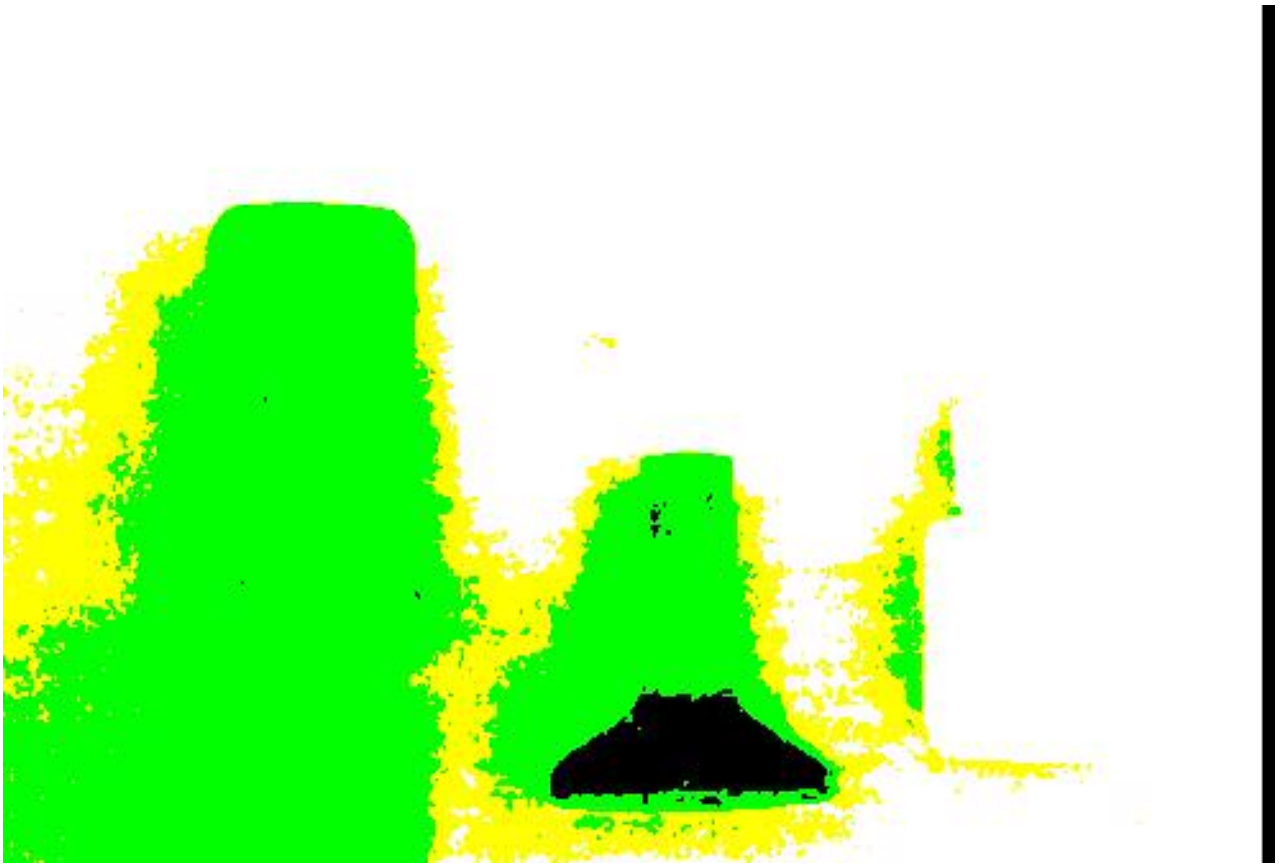

Fig. 1. Components of a Coyote Lure Operative Device (CLOD). From L to R, an assembled CLOD, covered with a layer of black plastic, screwed onto an angle-iron stake (driven into the ground), the commercial labware vial modified to slip over the stem of the acrylic CLOD core, and the labware vial as received from the manufacturer.

the top of the M-44 to prevent moisture and foreign matter from affecting the ejector mechanism. A "delivery" was scored if coyotes pulled the M-44 and the rubber stopper was ejected. For CLODs, a "delivery" was scored if the vial was punctured by coyotes and most of the syrup was gone.

After a combined total of 1,170 station-nights on the 2 ranches, there were no statistically significant differences in the number of deliveries to coyotes by CLODs (61) and M-44s (51), suggesting that the CLOD compared favorably with the M-44. Additionally, coyote responses to CLODs seemed vigorous. In many instances, all plastic parts were consumed and, occasionally, pulling and biting of the CLOD was so vigorous the stake was pulled from the ground. In this test, the W-U lure attracted significantly more coyotes to scent-stations and resulted in more deliveries to coyotes.

In another test, different amounts of W-U lure were applied to CLODs to determine the optimum amount for attracting coyotes and causing them to ingest the syrup contents of CLODs. After 520 station-nights, CLODs with 0.50 cc and 0.10 cc amounts received approximately equal coyote visit rates (12% and 13%, respectively), but those with 0.02 cc and no W-U lure (controls) received significantly less (4% each). Coyotes ingested the syrup contents of 9 CLODs with 0.50 cc of W-U lure, 8 CLODs with 0.10 cc, 2 CLODs with 0.02 cc, and 0 CLODs with no W-U lure. Although these differences were not significant, they suggest that at least 0.10 cc of W-U lure should be used to encourage coyotes to puncture CLODs and ingest the syrup contents.

Other coyote odor attractants were evaluated with CLODs to determine if greater rates of visitation and delivery of syrup to coyotes could be achieved. Four lures were evaluated on a south Texas property. Two were synthetic coyote lures, W-U lure and Abbreviated Synthetic Fermented Egg (SFE). Abbreviated Synthetic Fermented Egg (DRC-6503) was developed for the U.S. Fish and Wildlife Service Westwide coyote abundance survey to replace a fermented egg product (Bullard et al. 1978). The other 2 were commercially available coyote attractants, Carman's Distant Call Lure (CDCL) and Mast's #6. After 400 station-nights, CDCL proved to be equally as effective as W-U lure at attracting coyotes to CLODs and causing coyotes

to ingest the syrup. W-U lure (10%) and CDCL (13%) were both more effective in delivering syrup to coyotes than SFE (4%) and Mast's #6 (7%).

One of the original hypotheses during the development of the CLOD was that the odor from TMAD (the principal ingredient of W-U lure), which caused captive coyotes to lick and chew, would be important in encouraging free-ranging coyotes to bite the CLODs. In this test, CDCL was equally effective as W-U lure in causing free-ranging coyotes to bite CLODs. From these results, the ability of an attractant to attract coyotes to the CLOD is the major determinant of effectiveness. Once attracted to CLODs, coyotes will bite CLODs treated with different lures with similar frequency.

Ebbert and Fagre (1988) concluded that CLODs have significant potential as a delivery system because the syrup contents were consistently delivered to free-ranging coyotes. They suggested that further improvements may be accomplished by varying the CLOD's physical aspects, such as size, shape, and structure.

The CLOD was empirically developed and lacked a systematic analysis of each physical aspect of the CLOD to see if improvements could be made. By keeping most other characteristics constant, a characteristic such as CLOD size could be varied to optimize coyote response. This process could then be repeated for other characteristics. In a recently completed M.S. thesis, Ebbert (1988) described the results of field testing different CLOD designs.

In the first series of tests to optimize CLOD design, vials of different shapes were used to construct 4 CLODs with different physical dimensions. Tests were conducted on 4 properties in south Texas. After 412 station-nights, a vial slightly larger and wider than the original CLOD (designated as design "A") provided higher rates of puncture and ingestion of syrup by coyotes, but this was not a significant difference. The CLOD "A" design is shown in Fig. 1. This CLOD "A" design was further compared to the original CLOD design and another CLOD design on 1 property in south Texas for 201 station-nights. The CLOD "A" design was visited most often by coyotes and its syrup contents were most often consumed by coyotes, but the differences between CLOD designs were not statistically significant.

In another test of different CLOD designs, vials made of 2 plastics with different characteristics were used to construct the CLOD "A" design from the previous test. Polypropylene vials were more rigid and resulted in a harder CLOD. Low-density polyethylene vials were more flexible, providing a softer CLOD. A total of 212 station-nights exposure to coyotes on 2 properties indicated that 13% more low-density polyethylene CLODs were punctured and had their syrup contents ingested.

Additionally, attempts were made to enhance syrup ingestion by coyotes by cutting slits in the vials so the syrup would ooze out through the plastic coating of the CLOD, and the sweet taste would be experienced as the coyote bit the CLOD. No significant differences in ingestion rates between CLODs with slits (5.6%) and those without slits (9.4%) occurred after tests on 2 properties in south Texas. The lower ingestion rate for CLODs with slits suggests that this design will not offer advantages sufficient to compensate for potential problems with syrup leakage through the slits.

Although some design changes did not increase rates of syrup ingestion by coyotes, the overall process of systematic design optimization resulted in improving the effectiveness of the CLOD.

In a final test, the new CLOD design was compared to the original CLOD design and the M-44 device on 2 south Texas properties for 360 station-nights. The final CLOD design received 25% more visits by coyotes and had its syrup contents consumed more often (18 times) than the original CLOD design (9 times), but the differences were not statistically significant. There were not significant differences between the M-44 device (26) and the final CLOD design (18) in the number of device activations by coyotes, but the original CLOD design (9) was activated by coyotes significantly less often than the M-44 (26).

SUMMARY

The potential of the CLOD for delivering substances to coyotes, which was evident during its early development, has been partially affirmed in recent field tests. To date, only Rhodamine B dye has been used as an active ingredient in CLODs during field tests, although several toxicants have been successfully used in CLODs in pen tests (Marsh et al. 1982). One of the many needs in the application of the CLOD to coyote damage control situations is to obtain a reliable estimate of the proportion of a given coyote population which ingests the syrup when exposed to CLODs. Additionally, there is clearly the potential for further systematic testing of the CLOD design to improve efficacy. With continued efforts, the CLOD has the potential of being an additional tool for reducing coyote damage and obtaining information concerning coyote populations.

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