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Development of a String-Tracking System for Tranquilizer Dart Guns

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ABSTRACT: It was hypothesized that an inexpensive string-based tracking system could be developed to aid in the recovery of animals using tranquilizer dart delivery systems. Terminal velocity data were initially collected for 0.5-cc, 1.0-cc, 2.0-cc, and 3.0-cc conventional practice darts when fired from a .22-caliber cartridge-type dart gun at incremental distances of approximately 10-30 m. A commercially available archery string-based tracking system was modified and fitted to the dart gun. Power charges and pressure settings were changed in an attempt to achieve similar characteristics of darts when incorporating the string tracking system. During field testing, 10 raccoons were darted using the system, with 9 animals recovered. Ten white-tailed deer were darted and successfully recovered. All darts were readily recovered. Results of this study indicate the string tracking system is an inexpensive and reliable technology to facilitate the recovery of tranquilized animals and darts.

KEY WORDS: animal recovery, dart recovery, string tracking, tranquilizer dart

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INTRODUCTION

The value of remote delivery of anesthesia for capture of animals has been well documented over the past 50 years. Improvements in chemical immobilization agents have resulted in reduced mortality in deer. Mortality rates of deer captured using nicotine alkaloids were reported to range from 20-33% (Hawkins *et al*. 1967), and 14-33% for succinylchloride (Palmer *et al*. 1980, Ishmael and Rongstad 1984). Utilizing Ketamine-xylazine combinations (DeNicola and Swihart 1997, Peterson *et al*. 2003) and Telazol® (DeNicola and Swihart 1997, Kilpatrick and Spohr 1999), mortality rates in deer were reported as 0 - 2% and 0 - <2% respectively. While mortality rates decreased, recovery of tranquilized animals remains a challenge. Induction times for chemical anesthetics to safely immobilize an animal range from 3-15 minutes. As a result, recovery of a tranquilized animal with the potential to travel long distances is extremely difficult. Hawkins *et al*. (1967) indicated an average of 4.1 shots were required per deer recovered. In other studies, 54% (Ishmael and Rongstad 1984) and 52% (Kilpatrick *et al*. 1997) of tranquilized deer were recovered.

The development of darts capable of carrying radio transmitters and using conventional telemetry receivers has dramatically improved the recovery of deer. In a comparison study (Kilpatrick *et al*. 1996), researchers recovered all deer darted using the transmitter dart, compared to 52% recovery when using conventional darts. In another study, 86% of deer were recovered using the transmitter darts (Kilpatrick *et al*. 1997).

In addition to locating animals, failure to recover darts that have administered the anesthesia, as well as non-discharged darts if the animal is missed, creates potential hazards for humans as well as other animals. Using the radio transmitter darts, it was reported that 97% of the darts were recovered (Kilpatrick *et al*. 1997). No reports of losses using conventional tranquilizer darts were discovered.

While possessing significant advantages, radio transmitter darts may be cost prohibitive for some applications. A single use transmitter dart suitable for a 45 kg deer retails for $4.00 each. Transmitters currently cost $175.00 each, while telemetry receivers are approximately $800.00. In contrast, a conventional dart required to capture the same size animal retails for $3.15 (Pneu-dart Inc., Williamsport, PA).

The use of a string releasing mechanism to aid in the recovery of arrows has long been established for the sport of bowfishing. The Gametracker® Model 2500 (The Game Tracker, Flushing, MI) is a string release system originally designed for the aid in recovery of game animals harvested using archery equipment. A roll of string maintained within a plastic housing is attached to the bow. The free end of the string is secured to the arrow. Upon release, momentum of the arrow pulls the string from the housing providing a "string trail" to aid in recovery of the arrow and potentially the quarry.

The objective of this study was to determine if a string-based tracking unit could be developed to aid in the recovery of animals and darts when using tranquilizer dart delivery systems.

METHODS

Phase I: Ballistic Analysis

Initial terminal velocity analysis was conducted in an enclosed facility using 0.5-cc, 1.0-cc, 2.0-cc, and 3.0-cc practice darts (Pneu-Dart Inc.) without the string-tracking device from a distance of 9.15 - 27.43 m at 5-m increments. A .22-caliber cartridge-based dart gun (Model 193, Pneu-Dart Inc.) was utilized throughout the study and operated by a single individual. Initial .22-caliber charges and power control setting of the dart gun was based on information provided by the manufacturer (www.Pneudart.com). Ten shots of each size dart at each respective distance were completed from a portable firearm bench rest to minimize operator influence. The barrel of the dart gun was cleaned with a cotton swab and patch following each discharge. Complete disassembly and cleaning of the projector following each 10 shots, to minimize potential effects of powder residue from the

.22-caliber charge. Darts were fired into a 1.2-m × 1-m × 30-cm styrofoam block wrapped in burlap. A conventional bulls-eye target with a 15-cm diameter provided the primary target.

Terminal velocity was determined using a shooting chronograph (F-1 Chrony, Shooting Chrony Inc., North Tonawanda, NY) placed immediately in front of the styrofoam block. Each dart/distance combination was considered successful when the dart grouping on the target was within a 15-cm area. Failure to achieve this level of grouping resulted in termination of testing that dart size at that distance.

Following completion of the initial terminal velocity analysis, testing incorporating the string-tracking device was initiated. A Gametracker® was fitted with a 8-cm × 6-mm threaded rod, bent at a 90° angle 2 cm from the end of the rod, into the terminal end of the unit. A standard test-tube clamp was secured by glue to the opposite end of the threaded screw. The test-tube clamp was attached to the barrel, approximately 15 cm from the end of the barrel. This allowed the open end of the Gametracker®, housing the 770-m string roll (Eastman Outfitters, Flushing, MI) to be parallel with the terminal end of the dart gun barrel. The initial 50 m of a new string roll was removed and discarded. The terminal end of the string roll was threaded into a patch holder mounted on the end of a gun cleaning rod. The rod with threaded string was inserted through the dart gun barrel and retrieved through the receiver. The string was secured to the barrel of the polypropylene tail piece of the dart using multiple square knots. Excess string remaining from the knot was removed. Rolls of the tracking string were replaced as needed.

Alterations of .22-caliber charges and/or changes in power control settings when using the string-tracking system were initially conducted on a trial and error basis until consistent terminal velocities achieved were similar to those recorded when not using the system. Subsequent terminal velocity analysis was accomplished using the same procedures as previously described. Following ballistics testing, the diameter of the widest point of the terminal end of 30 unfired darts was measured using a digital caliper (Model #CD-6BS, Mitutoyo American Corp., Aurora, IL).

Differences in terminal velocity between darts with and without the string tracking system at the various distances were analyzed using Chi-square procedure of SPSS 13.0 (SPSS 2004).

Phase II: Field Testing

The string-tracking system was field tested by attempting to collect 10 raccoons (*Procyon lotor*) and 10 white-tailed deer (*Odocoileus virginianus*) on the Berry College campus. A combination of 200 mg/ml Ketamine and 40 mg/ml xylazine (The Butler Co., Dublin, OH) was dehydrated to a level suitable for chemical immobilization of mature raccoons using 0.5-cc darts. Two sizes of barbs attached to the needle of the dart were utilized. Ten raccoons were collected during three nights between 1900 h and 2100 h, within a barn utilized for housing horses. All animals were darted in roof truss areas from a distance of approximately 10 m. Ten minutes elapsed before attempting to recover tranquilized animals. Distance between the dart gun and location of recovered animals was recorded. Anesthetized animals remaining in the truss area were recovered and moved to ground level. All animals were muzzled. Barbed darts were removed and a topical antibiotic was applied to the skin to minimize chances of infection. Animals received an IV injection of 0.28 mg/kg of Yobine (Ben Venue Laboratories, Inc., Bedford, OH) to reverse the effects of xylazine. Ears were marked with a temporary ink for short-term identification purposes. All animals recovered and were released on site.

Ten white-tailed deer (approximately 45 kg) were collected at two locations on the Berry College campus. At each site, corn was utilized to attract deer to a specific location, providing a consistent darting distance of approximately 10 m. Deer were collected using 2.0-cc large-barbed darts containing a combination of 4 mg/kg Telazol® (Fort Dodge Animal Health, Fort Dodge, IA) and 20 mg/kg xylazine for chemical immobilization. A new roll of replacement string was utilized for each collection attempt. Approximately 10 minutes elapsed before locating tranquilized animals. Deer were initially blindfolded by placing a towel over the eyes. The dart was removed and a topical antibiotic was applied to the area to minimize potential for infection. Each animal received an identification ear tag and an IV injection of 0.28 mg/kg of Yobine to reverse effects of xylazine. Deer remained at the location and were observed from a distance until recovery was complete.

Distances and travel routes of deer captured were determined using the waypoint option of a Global Positioning System receiver (Garmin 12 XL, Garmin, Olathe, KS).

RESULTS

Velocity (m/sec), dart gun charge, and power settings for the varying dart sizes at different distances are presented in Table 1. Charge and power settings suggested by the manufacturer (www.pneudart.com) were utilized to determine terminal velocity of the various dart-distance combinations without the string tracking system. While an effective distance of up to 70 yards is stated for some dart sizes, distances of <30 m were tested in this study. Achieving a 10-shot grouping encompassing a 15-cm-diameter circle, as an indication of accuracy, was the determining factor for continuing to test each dart size at a further distance. This was rationalized on the basis that a potential target area of greater than 15 cm would greatly enhance the possibility of missing the animal completely or striking an unsuitable area, resulting in possible injury to the animal.

Achieving a 15-cm-diameter grouping was feasible for all distances tested for the 1.0-cc, 2.0-cc, and 3.0-cc darts without the string system attached. The 15-cm grouping criterion was achieved for 0.5-cc darts at the 3 closest distances (9.14, 13.72, 18.29 m). Variation in dart flight was approximately 2.54 cm on the horizontal axis for all dart-distance combinations However, flight variation on the vertical axis ranged from 5.0 to >20 cm. With the addition of the string system, achieving the 15-cm-diameter grouping among the 10 shots was

Table 1. Velocity (m/sec) and power settings of 0.5-cc, 1.0-cc, 2.0-cc, and 3.0-cc practice tranquilizer darts discharged at varying distances with and without the string-tracking system.

Distance m (yds)	Dart (cc)	Conventional Dart		String Tracking Dart	
		Power Setting*	Velocity (m/sec) (mean ± SE)	Power Setting*	Velocity (m/sec) (mean ± SE)
9.14 (10)	0.5	G1	50.83 ± 0.69	G2	48.87 ± 1.76
13.72 (15)	0.5	G1	53.75 ± 0.79	B5	56.05 ± 0.29
18.29 (20)	0.5	G2	67.09 ± 0.61		
9.14 (10)	1.0	G1	50.73 ± 1.00	G2	46.13 ± 1.47
13.72 (15)	1.0	G1	56.87 ± 0.76	G4	49.96 ± 0.29
18.29 (20)	1.0	G3	64.92 ± 1.41		
22.86 (25)	1.0	G3	62.23 ± 1.94		
27.43 (30)	1.0	G4	72.27 ± 1.40		
9.14 (10)	2.0	G2	54.04 ± 1.23	G3	46.96 ± 1.51
13.72 (15)	2.0	G3	63.51 ± 0.91	G5	53.00 ± 0.29[a]
18.29 (20)	2.0	G3	63.22 ± 0.49	Y4	59.10 ± 0.29
22.86 (25)	2.0	G4	70.36 ± 1.06		
27.43 (30)	2.0	G4	70.80 ± 1.05		
9.14 (10)	3.0	G2	62.15 ± 0.20	G4	62.90 ± 1.56
13.72 (15)	3.0	G3	54.51 ± 0.86	G4	54.91 ± 1.66
18.29 (20)	3.0	G4	66.22 ± 0.52		
22.86 (25)	3.0	G4	68.20 ± 1.08		
27.43 (30)	3.0	G4	63.88 ± 1.96		

[a] Differences in velocity ($p < 0.05$) between conventional dart and string-tracking dart within rows.

* Power Setting

Cartridge
B = .22-caliber blank, brass # 2 (low charge)
G = .22-caliber blank, brass # 3 (moderate charge)
Y = .22-caliber blank, brass # 4 (high charge)

Power Control (1- 5)
1 = lowest gas port
5 = highest gas port

consistently accomplished at 9.14-m and 13.73-m distances for all darts. Accuracy for 2-cc darts at the 18.29-m distance was also acceptable. Increasing the charge and/or power control setting was essential to achieve similar velocities of darts with the string compared to darts without the string attached. While variation in the vertical axis was similar to the conventional dart flight, horizontal deviation in accuracy ranging from 2.5 to 15 cm occurred when the string-tracking system was included. In addition to greater variation in both horizontal and vertical impact sites observed, higher charge and/or power settings beyond those presented for each dart-distance combination frequently resulted in string breakage at or near the muzzle or velocities far exceeding those when the string system was not used.

During field testing, 10 raccoons were darted using the system with a total of 9 animals recovered. Five attempts were made using 0.5-cc darts with small barbs (2 mm). While administration of the immobilization agent was successful, none of the small barbed darts remained attached to target animals. Four of 5 animals were recovered within the livestock barn where darting occurred. The fifth animal exited the barn and was not recovered. Five additional raccoons were collected using 0.5-cc darts with larger wire barbs (5 mm). Four of 5 attempts resulted in the dart being securely attached to the animal until physically removed. Four raccoons were recovered within 30 m from the initial site of dart impact within the livestock barn. The fifth raccoon was recovered, dart and string attached, approximately 100 m away from the barn within the branches of a white oak (*Quercus alba*) at a height of 3 m. In all cases, no string breakages occurred and all darts were readily recovered.

Twelve attempts were made to collect 10 white-tailed deer at a distance of 9.14 m. In the 2 failed attempts, darts fell far short of the target animal and appeared to lack sufficient velocity. Failure to remove sufficient string (>50 m) from each replacement roll was found to have a significant effect on dart flight during ballistics testing.

Six deer were collected in one location. All deer traveled between 150 and 300 m. One animal was collected in an adjacent livestock pasture consisting predominantly of Bermuda grass (*Cynodon* spp.) with interspersed hardwoods. The remaining 5 animals traveled through dense mixed pine-hardwood forest with significant under story shrub growth. Visibility in these areas was generally less than 20 m. While the deer collected in the livestock pasture traveled in a relatively straight line, those that darted near the dense forest areas made significant numbers of turns and loops before succumbing to the chemical agents.

Four additional deer were collected at a second location that consisted of Bermuda grass pasture with interspersed hardwoods. Similar to most deer recovered at the other location, none of these animals demonstrated a direct flight path between the site of darting and succumbing to the chemical agent.

In two instances, the string line broke, approximately 10 and 20 m respectively, from the imbedded dart. In each case, the attached end of the string was located within 20 m from the broken line. Locating the string end attached to the dart was accomplished by continuing in the general direction of line prior to the break. In both cases, deer had succumbed to the tranquilizer apparently near the time of string breakage. All darts were recovered from the 10 deer collected using the string dart tracking system.

DISCUSSION

Results of this study indicate that the concept of an inexpensive string tracking system to aid in the recovery of animals and darts is feasible. Variation in dart flight was particularly noticeable in the vertical axis with and without use of the string-tracking system. Differences in the diameter of the tail-piece of the dart, measured at the widest point, ranged between 12.95 and 13.05 mm (12.98 mm ± 0.03). Kilpatrick *et al*. (1997) reported similar variation in dart diameter and indicated that a deviation of more than ±0.05 mm in the tail-piece caused noticeable variation in dart velocity and flight. Greater variation in the horizontal axis when using the string tracking device was likely due to drag produced on the dart during unrolling of the string.

Accuracy and effective darting distance were compromised to some degree as a result of the string but remain within acceptable levels for some applications. Alteration in the .22-caliber charge and/or power settings was necessary to overcome the effects of the string. The greatest challenge to improving the concept would appear related to characteristics of the string and its ability to unwind with minimal binding and subsequent drag. The rolls of string designed for use with the Gametracker® are somewhat flattened, similar to dental floss with reported test strength of 11 lbs pressure. The string is wrapped in such a manner to facilitate unwinding from the inside toward the outside. String in the interior area of a new roll is tightly packed and tended to create a significant binding problem and excessive drag effect detrimental to dart flight. As a result, it was necessary to remove at least the initial 50 m of line prior to use. Additional trials using different types of string were unsuccessful. In most cases, material that was round, such as monofilament, interfered with the ability to load the dart into the chamber. The ideal string would likely need to be flat to minimize interference with the dart within the barrel. This material should also have a higher tensile strength to minimize the chance of breakage and to unroll in such a manner to minimize resistance. Addressing these issues will likely improve dart flight characteristics and further enhance accuracy and effective distances.

An interesting observation occurred due to the unique feature of being able to trace the exact escape route of deer following darting. During the course of this experiment, multiple deer were observed in the immediate area (0-100 m) of the target animal. Regardless of the initial direction taken by the target animal immediately post-darting, all animals ultimately traveled in the general direction taken by other startled deer or toward those in open areas exhibiting no initial response to firing of the dart gun. As a result, several deer escape routes included multiple turns, full circles, and one individual completed a figure-8 pattern before the chemical restraint took effect. This would suggest that observing the response of non-target animals in the area may be a better indicator of the location of the target animal when not incorporating a dart tracking system.

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