Application Methods for Paste Bait Formulations in Control of Ants in Arboreal Situations

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Abstract. Control of invasive ant species has predominantly been through the use of granular baits. These baits are not suitable for ant species that nest in trees and vegetation such as *Wasmannia auropunctata*, recently introduced to the Big Island and Kauai, Hawaii. In recent years there has been an increasing interest in the use of gel and paste baits for control of some invasive ant species. However, application of these bait types is difficult and time consuming. Here we describe new application methods for gel and paste baits in arboreal situations.

Key words: paste bait, ants, ant control, application equipment, *Wasmannia auropunctata*

Introduction

The introduction of *Solenopsis invicta* (the red imported fire ant) to the continental USA in the 1930s led to substantial effort and expenditure of resources on research for control methods (Williams 1983, Williams et al. 2001). Although there are many contact pesticides registered for control of ants, baits have long been regarded as the most efficient and effective means of control (Williams 1983). Foraging ants quickly find baits (a combination of an attractive food, toxicant and carrier) which they take to the parent colony where it is shared with nestmates and the queen through trophallaxis.

Active ingredients suitable for use in ant baits should exhibit delayed toxicity, good efficacy when diluted by trophallaxis, non-repellency and ease of formulation with carriers and attractants. (Stringer et al. 1964). Despite extensive testing, few active ingredients have proved fit for this purpose (Levy et al. 1973, Williams 1983, Williams et al. 2001). In recent years, a number of new active ingredients have entered the market (Stanley 2004), and today there are a number of effective bait products available, giving the practitioner a wider range of choices. With some exceptions, they are formulated in a similar way: using defatted corn grit as the carrier and soybean oil as the attractant. This granular formulation allows for easy distribution over the ground, ease of packaging and long shelf life.

The baits originally developed for *S. invicta* are also effective against some other ant species, but not all ant species are attracted to them. Additionally, granular baits can not be effectively applied to vegetation where arboreal ant species forage and nest. One invasive species *Wasmannia auropunctata* (the little fire ant) nests in trees as well as on the ground, forming three-dimensional super-colonies (Spencer 1941, de Souza et al. 1998, Wetterer and Porter 2003, Le Breton et al. 2004). Efforts to control this species with granular baits have proved problematic in all but simple ecosystems, and one reason offered has been an inability to control the arboreal colonies, which are able to re-colonize the ground layer after treatment (Souza *et al*. 2008).

Baits formulated as pastes or gels have advantages for control of little fire ants as they are able to be applied to tree trunks, branches and vegetation. To date, however, the task of applying paste baits has been difficult and time consuming. Here, we describe some new tools for applying paste baits to vegetation.

Methods and materials

For the testing medium, we used a 3:5 mixture of smooth peanut butter and water to which an emulsifier (xantham gum, 0.5%) is added (PB matrix). This mixture resembles thick pancake batter when properly mixed and is a medium that quickly attracts *Wasmannia auropunctata* foragers. The viscosity of this mixture has proven optimal for discharge through the appliances tested here. We have used a slightly thicker mixture (1:1 PB and water) with a toxicant added for *W. auropunctata* eradication programs in Vanuatu and Papua New Guinea, however, the thinner mixture proves equally attractive (pers. obs.).

Pneumatic grease gun. Grease guns are used in the automotive and engineering industry to inject lubricating grease into bearings. They can be hand powered, battery powered or run on compressed air provided by a compressor. Air powered grease guns have an output pressure of approximately 41,000 k.p.a. (6000 lb per square inch) with an input pressure of 200–1000 k.p.a. (30–150 lb per square inch) depending on manufacturer. When loaded with grease, they are capable of propelling a 1 gram quantity several meters via a spring-loaded piston that forces a preset quantity of grease into the nozzle. Grease guns have previously been used to propel Splat™ (a carrier for semiochemicals) by ISCA Technologies (P.O. Box 5266, Riverside, California 92517; http://www.iscatech.com). It is reasonable to assume that a pneumatic grease gun could also be used to propel the PB matrix. The following grease guns were purchased and tested for this purpose: Central Pneumatics, model 0218 (Central Pnuematics Inc. 5155 Timberlea Bvd Mississauga, Ontario Can.); Campbell Hausfeld model TL103700AV (Campbell Hausfeld, 100 Production Drive, Harrison, OH 45030); Alemite model F100 (Alemite Corp. 167 Roweland Drive, Johnson City, TN 37601); Ingersoll-Rand model 590 (Ingersoll-Rand Company, Corporate Center One, Centennial Ave, Piscataway NJ 08854)

All four grease guns were purchased through an internet sales site, two budget models and two heavy-duty models (Table 1). These were tested with the PB matrix to determine their suitability for applying the bait matrix. Lubricating grease and the PB matrix have different coefficients of friction and therefore, the PB matrix was expected to act differently on the moving parts of the grease guns: the piston assembly and the rubber plunger inside the cartridge.

Texture paint applicator. Texture paint hopper guns are used in the painting industry to apply a textured surface to drywall or concrete. This finish is achieved by using a thick medium with a consistency of pancake batter that is propelled in splatters onto a wall or ceiling. They are powered by mains voltage or by compressed air. We tested a Wal-board Tools™ Texture Pro 200™ manufactured by Wallboard Tool Co. Inc., PO Box 20319, Long Beach, California, which uses compressed air as the propellant.

Air supply options. Several options for the supply of compressed air to these tools were tested. First, a 1.5 hp electric compressor with a 6-gallon tank, (model Husky™ h1506FWH, Husky Tools. 2455 Paces Ferry Rd, Atlanta, Georgia) was used for initial testing and calibration. This compressor performed adequately and compressors with similar specifications are expected to give similar results. None of the tools tested needed high air volumes but a drop in spray distance was noted when using the texture gun with some alternative air supplies.

Although electric compressors are useful for treatment in urban locations, many eradication and control projects extend well beyond areas where mains power is available. Air compressors with gas engines are useful in agricultural situations where tractors or other

Table 1. Details of the four grease guns tested. Prices include shipping to Hawaii.

Model	Price US$	Weight (kg)	Maximum k.p.a. input	Throw distance (m)	
				600 k.p.a.	800 k.p.a.
Campbell Hausfeld	25.33	1.3	700	6	
Central Pneumatics	29.94	1.25	700	6	
Alemite	65.98	1.8	1000	6	7.5
Ingersoll-Rand	99.99	1.6	1000	5.5	6.5

machinery can be used to transport the unit, but too heavy and difficult to maneuver in natural areas or steep terrain. Several more portable options were tested.

Jacpac™ portable CO_2 air supply system (Supplierpipeline Inc. 490 Dutton Drive, Unit A1 Waterloo, Ontario, Canada. 2L 6H7). The Jacpac utilizes refillable pressurized tanks of CO_2 with the same thread fitting as tanks used to propel paint balls in air guns. The tanks can be re-filled by paintball retailers or from a CO_2 bulk tank that has a siphon tube and the correct adapter. Filling is by weight. The unit is extremely portable and clips onto a belt for normal use. The control unit has a regulator that allows output pressure to be set from 0-800 k.p.a. (0-120 lb p.s.i.) and uses standard air tool fittings on the output.

Campbell Hausfeld FP2071 portable rechargeable compressor (Campbell Hausfeld, 100 Production Drive, Harrison, Ohio 45030). The Campbell Hausfeld FP2071 portable compressor weighed approximately 30 pounds and can be carried by one person over even terrain. It has a 1.5 gallon air tank that can be filled before departing and the 12 volt rechargeable batteries automatically refill the tank as air is discharged.

Palmgren 92102 HipShot™ Tankless Compressor (Palmgren Steel Products, Inc. 914 North Kilbourn Avenue Chicago, Illinois 60651). The Palmgren Hipshot portable air unit is designed to allow air powered equipment to be used in confined places or for small tasks that do not warrant setting up and using a larger compressor. It was powered by a rechargeable battery but does not have an air tank. The compressor generates enough pressure for a short burst then requires 2 seconds to recharge.

Scuba tank adapted to supply compressed air to pneumatic tools. A 6 m^3 (64 $ft^{3)}$ aluminum scuba tank rated at 21,000 k.p.a. (3000 lb p.s.i.) was adapted with a variable regulator and a take-off hose fitted to take pneumatic tools. The tank was fitted with a backpack support that allowed it to be carried by an operator. Although a little heavy (15 kg), an operator was able to carry the tank and regulator through most terrain and the unit provided a portable supply of compressed air.

Testing methods. The output of each grease gun and the texture gun was measured by firing it twenty times and weighing the PB matrix that was discharged and calculating mean weight for each discharge. Each air supply option was tested to determine the total output per tank or between charges, by counting the number of times the Alemite grease gun could be fired before the air supply was exhausted. To avoid repeating this for the texture gun, the relationship between the output of the texture gun and the Alemite grease gun was calculated by measuring output of each unit for the same quantity of air. Using the Jacpac CO_2 air supply, we measured the amount of PB matrix applied for fifty discharges and measured the amount of CO_2 used by weighing the container before and after use. The distance each unit could propel the PB matrix was measured by firing each unit in a horizontal direction from waist height several times. Mean distance was measured to the nearest 50 cm.

Results

Grease guns. The grease gun from Central Pneumatics was the lightest weight of the four units tested. The reservoir was filled with the bait matrix and tested with an input pressure of 600 k.p.a. (90 lb p.s.i.) Small 1-gram quantities of bait were propelled approximately 6 meters, making it a good tool for applying bait to taller trees. However, the Central Pneumatics grease gun consistently jammed and the piston would not return to the rest position. This necessitated dismantling the nozzle and the one way valve at the head of the gun and manually forcing the piston back. It appeared that the return spring was not able to return the piston to the rest position, possibly due to the increased co-efficient of friction of the PB matrix.

The Campbell Hausfeld grease gun appeared to be better quality than the Central Pneumatics gun and performed much better. The piston did not jam at any time and it operated smoothly. Occasionally, the spring loaded plunger built into the cartridge would stick, but this was easily resolved by pulling, then releasing the loading handle. Firing distance was approximately 6 meters at 600 k.p.a. (90 lb p.s.i.). input pressure.

The Alemite model F100 grease gun was heavier than the two budget units we tested and had a higher maximum input pressure of 1000 k.p.a. (150 lb p.s.i.). The Alemite performed flawlessly. Neither the piston or the rubber seal jammed when tested at 600 k.p.a. (90 lb p.s.i.). and 800 k.p.a. (120 lb p.s.i.) The extra input pressure resulted in a slightly further throw of approximately 7.5 meters.

The Ingersoll-Rand model was tested at both 600 and 800 k.p.a. (90 and 120 lb p.s.i.). It had a shorter throw distance than the Alemite (see Table 1). Additionally, the restrainer that holds the plunger in the fill position would sometimes slip. When this occurred, the contents would be violently ejected. However, it had one distinct advantage over the other guns. When the trigger is kept depressed, the gun fires repeatedly at a rate of one shot per second. Although the Jacpac, cordless compressor, and the Palmgren Hipshot were unable to supply sufficient airflow for repeated firing, an electric compressor was able to deliver sufficient air.

The Texture Pro 200. The texture gun has a hopper capable of holding several kilograms of medium. On the test compressor with 170 k.p.a. (25 lb p.s.i.) output, the spray distance exceeded 6 meters when used with the largest nozzle. When used in short bursts of approximately 0.5 sec. a 50-60 cm circle of small (<1 cm) splatters spaced on average 10 cm apart formed on target vegetation to a maximum height of 4-5 meters. Mean weight of each burst was 6 g. Smaller nozzles reduced this distance and produced a finer spray of bait. Making the bait mixture thicker (1:1 peanut butter and water) resulted in poor flow through the gun.

Air supply options. The four air supply options we tested differed markedly in performance and are compared in Table 2.

The Jacpac performed very well with a 600-g CO_2 bottle providing a flexible, portable source of compressed air with the ability to alter output pressure via a regulator. The manufacturer states that a 600-g bottle of CO_2 should be sufficient to distribute the contents of a 480-g grease gun cartridge six times. However, on testing, 30 g of CO_2 was needed to discharge the grease gun 50 times. Therefore, a 600-g CO_2 bottle would be expected to provide 1000 shots or 1kg of bait (Table 2)

The Campbell Hausfeld compressor worked well with both the grease gun and the texture gun. On test and with a fully charged battery, it was able to deliver 300 shots with a grease gun.

The Hipshot proved suitable for use with a grease gun but not the texture gun because the texture gun requires a continuous supply of air at 170 k.p.a. (25 lb p.s.i.), which the Hipshot was unable to deliver. One disadvantage of the Hipshot was that output pressure

Table 2. Comparison of air supply options and approximate bait output per charge or refill. Purchase prices of equipment include shipping to Hawaii.

Model	Price US$	Refill/recharge cost	Bait output (kg) (grease gun)	Bait output (kg) (texture gun)
Jacpac (with 20 oz CO_2)	84.60	8.00	1.0	12.0
Campbell Hausfeld	210.99	0.02	0.3	3.6*
Palmgren Hipshot	55.49	0.02	0.16	Not tested
Scuba tank and fittings**	335.00	5.00	4.1	49.2*

*By inference; **Purchased locally

was fixed at 770 k.p.a. and could not be altered. To change pressure, a regulator would need to be fitted in-line on the air hose. Additionally, it took two seconds for the unit to recharge which means the operator had to wait for the compressor to recharge between shots. On test, with the two rechargeable battery packs supplied, the Hipshot was able to provide 160 shots with the grease gun, equivalent to 160 g bait.

The scuba tank provided the greatest supply of air. On test, a single tank was able to deliver 4100 shots with a grease gun (Table 2) and by inference dispense 49.1 kg of PB matrix through a texture gun. An additional useful feature of the scuba tank was the ability to use it to fill compressed air tanks that are compatible with the Jacpac air supply.

Discussion

While the red imported fire ant *Solenopsis invicta* recruits more readily to granular baits (Kidd et al. 1985), this is not necessarily true for other ant species (Stanley and Robinson 2007). In recent years there has been increasing interest in the use of liquid, gel and paste baits (Greenberg et al. 2006, Stanley and Robinson 2007, Brooks et al. 2008, Cooper et al. 2008) due to their attractiveness, efficacy and apparent ability to control pest ants in agricultural situations. This has prompted some manufacturers to explore the commercial viability of liquid baits (Braness 2002). However, granular baits offer a significant advantage for operators over liquid and gel baits as they are much easier to distribute. In the past, liquid and gel baits were usually deployed via bait stations (Oi et al. 1994, Greenberg et al. 2006, Nelson and Daane 2007, Battany n.d.), a time-consuming and often impractical task when treating large areas. Now, for paste and gel baits at least, there are practical alternative application options suitable for large-scale use.

Forest ant species such as *Wasmannia auropunctata* often have arboreal nests that have no contact with the ground (Spencer 1941, Fabres and Brown jnr 1978). This aspect of their biology has made little fire ants especially difficult to control as arboreal colonies remaining after treatment are able to recolonize the ground layer once treatment ceases. The tools described here will allow the placement of paste baits as far as 8 meters from the ground, thus able to reach the foraging range of most arboreal colonies.

We acknowledge that only a single grease gun of each model was tested and that there may be some within-model variation in quality that may have affected the results. Of the grease guns tested, the Alemite F100 and the Ingersoll-Rand were the most suitable for the task of baiting. They were well constructed and had a maximum input pressure of 1000 k.p.a.. The Alemite gun was the easiest to fill as the plunger has a positive lock with less chance of slipping. Care needs to be taken in cleaning and lubrication because the PB matrix eventually dries to form a solid, and this can clog the cylinder, valve and nozzles. Therefore the unit should be thoroughly cleaned on a daily basis. The internal components of the grease guns also need regular lubrication with pneumatic tool oil which can be manually applied at the beginning of a day's work.

The texture gun provides an efficient and effective way to rapidly apply bait to vegetation up to a height of 6 meters, where most LFA are found. It is also useful for dispensing paste baits on the ground and difficult to reach areas such as over steep terrain and onto thick vegetation. It is a more efficient way of dispensing large amounts of bait, and in conjunction with the grease gun for more accurate bait placement, provides a means of applying baits to an entire site.

The maximum height that baits can be dispensed with these tools will vary with the air supply option used, terrain and wind. The horizontal throw distances reported here will be greater than the height that these tools can reach. However, an operator is able to hold both the texture gun and the grease guns at a height of ~2 meters, and this adds to the total delivery height.

The choice of air supply will be determined by the site to be treated. In agricultural situations, a gasoline compressor is ideal as it can be tractor-mounted and driven between the crop rows. For situations where access is an issue, the Jacpac portable CO_2 system was the lightest and most convenient of the options tested and provided substantial output of 1 kg (grease gun) and 12 kg (texture gun) with a single 600-g cylinder. This system however, has several disadvantages. First, the CO_2 tanks, or the ability to have them filled, may not be available at all locations. Adapters are available to decant liquified CO_2 from bulk bottles, however access to such bottles may not always be possible. Further, liquified gases are sensitive to ambient temperature changes, and at temperatures over 49°C there is a possibility of explosion. CO_2 bottles therefore need to be kept cool at all times and should be carefully stored when carried in motor vehicles. Although we did not test this, the Jacpac can also be powered by compressed air tanks that can be refilled with a scuba tank. This would therefore be a useful option in combination with the scuba tank air source. The cordless compressor and the Palmgren Hipshot were generally not suitable due to the low capacity of either system. However, in some situations such as urban allotments, these items may well be adequate. Scuba tanks, although heavier, are more readily available and are also inexpensive to refill. The scuba tank we tested provided ample compressed air for a day's work in the field and may be the most available option for isolated locations.

A discussion of the regulatory issues pertaining to the mixing and deployment of the type of bait matrix tested here is beyond the scope of this paper. Additionally, pesticide regulations vary substantially between states and between countries. With these additional application tools, gel and paste baits are much easier to apply and this removes one of the major impediments to their use. Some adjustments may be necessary for optimum distribution of pastes and gels with different viscosities and it is hoped the information presented here will serve as a starting point for practitioners. We are certain that as these tools are used by others, additional refinements and improvements will be made.

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