COOPERATIVE EXTENSION
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Electric Fence: Non-Chemical Wild Pig Deterrent

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Intrusion of wild pigs (or feral pigs) and other animals into the production area is a serious challenge in Hawaii, particularly in vegetable production systems, affecting both yields and food safety. Although the Food Safety Modernization Act (FSMA) and GAP Harmonized Audit do not require exclusion of grazing, working or intruding animals, growers must take proactive and reasonable steps to prevent growing and food packing areas from being contaminated by animals. The intent of this publication is to give an introduction on how wild animals can be excluded from production areas using an electric fencing system in combination with other control strategies.

An electric fence consists of an energizer, fence posts, a metal wire held by the posts and a ground rod (s). The energizer also known as a charger, zapper or shocker is the power source of

the system. It has the ability to convert the main power source (usually 12 volt or 110 volt) to a higher voltage pulse (ex. 8,000 volts or 8 kilovolts (kV))(Figure 1). The energizer's positive terminal is connected to the fence wires and the negative to a ground rod. It doesn't matter if a fence has one, two or more wires, they all should be connected to the energizer positive terminal, thus connecting to the positive side of the circuit. Pulses of electrical current will only be emitted if the circuit is closed. When an animal touches the electrified wire, its body closes the circuit between the positive and negative terminals of the energizer, just like a switch closes a circuit to turn on a lightbulb. Electricity then travels from the energizer, through the fence wires, through the animal hair, skin, body and hooves, into the ground to the ground rod and back to the energizer.

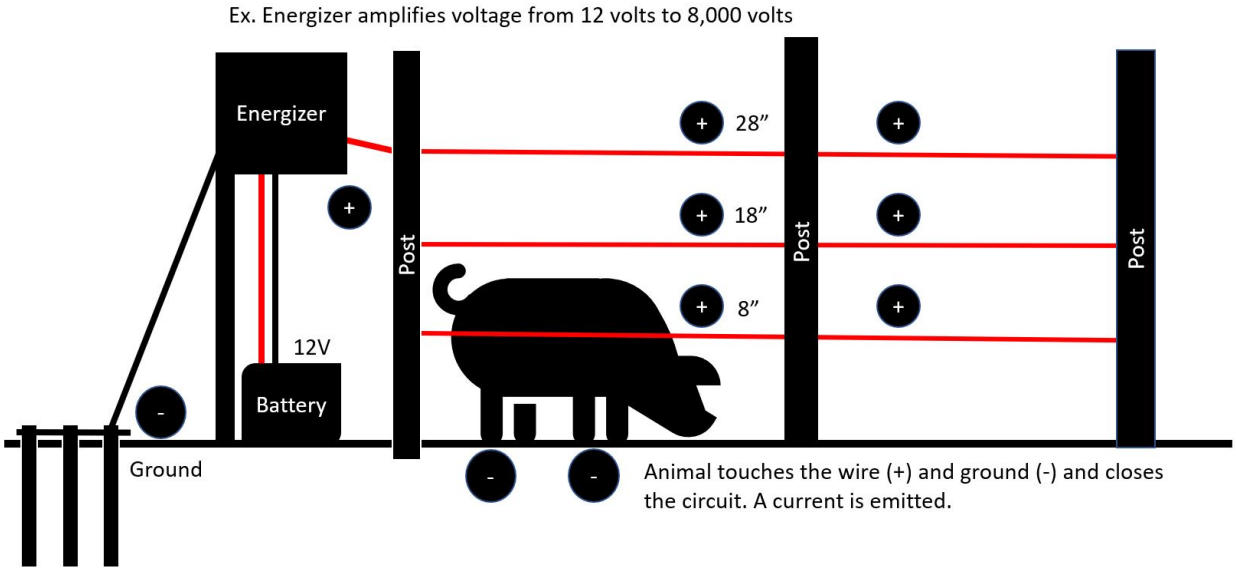

Figure 1. Depiction of an electrified fence system and how the animal closes the circuit. When the circuit is closed, an electrical shock is felt by the animal and deters it from entering the production area

Current, voltage, resistance

Ohm's law states that the current through a conductor is directly proportional to the voltage across the two points and inversely proportional to the conductor's resistance.

$$Current = \frac{Voltage}{Resistance}$$

In our case, the conductor is a complex path made of wire cables, fencing cables, the animal touching the fence, the ground and the grounding rod. For the shock to be effective, we want the current to be within the recommended ranges. According to Ohm's law equation, the current is larger when voltage is large and when resistance is low. The maximum voltage of a fence system is determined by the energizer. Make sure to buy a transformer that supplies a voltage appropriate to the animals that you are trying to keep out of your field. The resistance

of the circuit is the sum of the resistance of each element in the circuit (i.e. wire material, animal body, etc). While manufactures report that pigs can be deterred with a voltage of 5 kV, replicated research trials conducted by Reidy et al. (2008) and Lavelle et al. (2011) found that a range of 8-10 kV was effective in deterring feral pigs using different types of wire systems.

As a result, one should try to make the resistance of each part of the circuit as small as possible, in order to have a high current shocking the animal. To decrease resistance of the circuit the following steps can be taken:

- The wire should be thicker (lower AWG gage number) as the perimeter of the fenced area becomes larger (Figure 2). Most general use fences use galvanized 14-gauge or 17-gauge wire.
- Install more than one ground rod, spaced 10 feet, preferably in areas with permanently humid soil. Proper grounding optimizes the electric fence system.
- Wire connections between ground rods, posts and the energizer wire terminals should be metal-to-metal contact. Brush or sand oxidized metal surfaces before making the connection.
- Ground rods should have copper coating and connectors (8 feet ground rods can be bought at Home Depot for less than $20) or made with a steel rebar.
- Mow vegetation around the fence to increase contact between animal hooves and the soil. Dry vegetation has particularly high resistance.

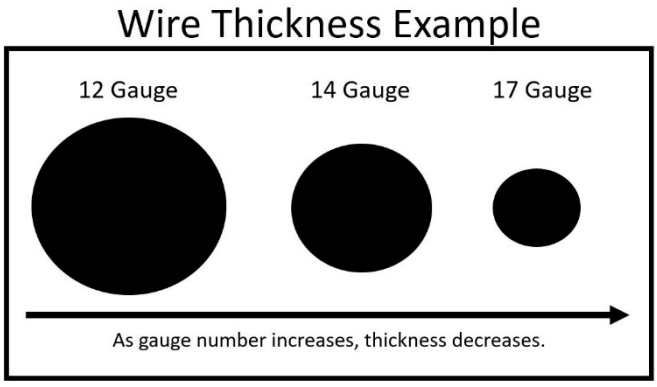

Figure 2. Visual example of how thicker wires have smaller American Wire Gauge (AWG) numbers.

Similarly, one should make sure that the two branches (positive and negative) of the circuit are electrically isolated as much as possible. Take the following steps:

- Mow vegetation growing around the fence that are tall enough to touch the positive wires
- If the posts holding the wire are made of metal, plastic insulators can be used to hold the wire. Alternatively, a piece of PVC pipe can be inserted onto the fence posts to insulate them.

Fence Design

Wire/ Netting

Choice of fence wire range from aluminum wire, galvanized wire, netting and poly wire that consist of UV-resistant nylon string with metal wire embedded in it. Electric netting is typically

used for poultry and smaller animals. Fence wire can have the shape of a rope or of a tape (poly tape). Generally, poly wire is cheaper and lighter than galvanized wire, but it doesn't offer the mechanical resistance of galvanized wire and has larger electrical resistance per unit length. Thus, poly wire is recommended for slower moving animals and shorter length systems. For feral pigs galvanized wire is recommended (at least 12.5-gauge wire). Being thicker than the poly wire conductors, galvanized wire can cover miles of electrified fence.

Poly wire (14-17-gauge) is often used for shorter distances.

A 12 gauge galvanized wire is often recommended for wild pig fences as it can cover miles of fencing.

Figure 3. Example of thickness of different wires used in electric fencing.

Figure 4. Example of a fence built with step-on plastic posts and aluminum wire (left) and detail of poly tape (right).

Post

Various post designs are commonly used. An affordable and effective solution is using T-posts lined with PVC (a 1½ inch PVC pipe fits on a T-post) and ¾" PVC pipe fits on a steel rebar to hold the wire, with a distance between posts of about 4-5 feet. Step-on plastic or fiberglass posts are available commercially for about $2 apiece. These do not require insulators, but they are not as resistant as T posts. Wooden posts also do not require insulators, but wooden post installation does require digging holes, as compared to T-posts that can be pounded into the ground. A hybrid solution was used at the Waimanalo Research Station, using T-posts at the corners of the fence and plastic step-on posts on the sides. Wire height should be adjusted for the specific animal that the fence is intended for.

Figure 5. Example of an energizer powered by external 12V battery (left), T-post with plastic insulators holding poly tape (center) and step-on posts holding poly tape (right).

Energizers

Figure 6. Example of an energizer powered by D type batteries or external 12V battery. Note the display showing the voltage of the fence and of the external battery.

Figure 7. Example of a solar-powered energizer with built-in internal battery. Note the red (positive) and black (negative) terminals.

Many manufacturers make energizers (Kencove, Stafix, Zareba, Power Wizard) and many retailers sell them (Amazon, Home Depot, Waimanalo Feed, etc). When selecting an energizer, consider how it will be powered. There are models powered with a normal electrical plug (110 Volt AC) if electricity is available at the location. Battery and solar powered models consume very little electricity so a large battery can last months. The disadvantage of battery systems is the nuisance of periodically moving the battery to a charging station and risks of theft. Solar powered models with smaller built-in batteries are also available.

The energizer voltage should be selected depending on the animal that you are trying to keep out of the fence and the resistance of the fence system. Typically, energizers deliver 2,000 to 5,000 Volt (equivalent to 2 to 5 kV or kilo Volt). For feral pigs consider a charger with at least 5,000-volt output.

Low impedance energizers do not shock continuously, rather, electricity is released over a very short period of time (fractions of a second) every few seconds. In some models the time between shocks or the pulse duration (pulse time) can be adjusted, but this also affects fence effectiveness and battery duration.

The performance of different models is reported by manufacturers in various units.

Terminology	Type Units
Joules	Unit of energy
Watt Ex. 1 Watt Ex. Watts	Unit of energy/ time Ex. 1 joule/ second Ex. Volt x Amps
Volts	Units of electrical potential
Amps Ex. 1 Amps	Units of current or electricity Ex.1 watt / 1 volt
Pulse	Short burst of electricity

Figure 8. Units used to report performance of electrified fence systems

One can think of potential (volts) as how effectively electricity is “pushed” through resistances. So, a fence with higher voltage will be able to shock an animal with thick hair (greater resistance) while a low voltage fence may not. The electrical current (amps) is what causes the numbing pain to the animal and should be used as the real value to compare energizers (Cadwallader and Cosgrove. 2012).

Figure 9. Example of a fence tester with a hook to hang it to the fence wires and a needle to connect it to ground.

Voltage Testing

The actual voltage in various points of an electrified fence can be measured with a fence tester. A tester like the one in Figure 9 should be connected to the fence wire and ground. Some energizers have displays and built-in voltage meters that display the fence voltage automatically.

Safety

Exercise caution if visitors, volunteers, and children are around the area. Proper signage should be posted and visitors should follow company policy when on the farm (Figure 10).

Figure 10. Example of a fence built with T-posts, note the signage and the grounding rod under the energizer and the 1 ½ inch PVC pipe used to insulate the T-post.

Fence effectiveness

Electric fences are not 100% effective, but Reidy et al. (2008) found that electric fences reduced animal intrusion into the production area by 65% compared to no electricity. The study also showed that there was no significant difference between 1, 2, or 3 strand wires but there was 50% less crossings for 2 wire systems and a 40% reduction for 3 stranded wires charged at 8.5 kV or 8,000 volts. The height of the polywire strands was 20 cm (one strand), 45 cm (two strand), and 71 cm (three strand) above the ground.

Strand one	20 cm	8 inches
Strand two	45 cm	18 inches
Strand three	71 cm	28 inches

Figure 11. Wire distances from the ground used in the Reidy et al. (2008) study.

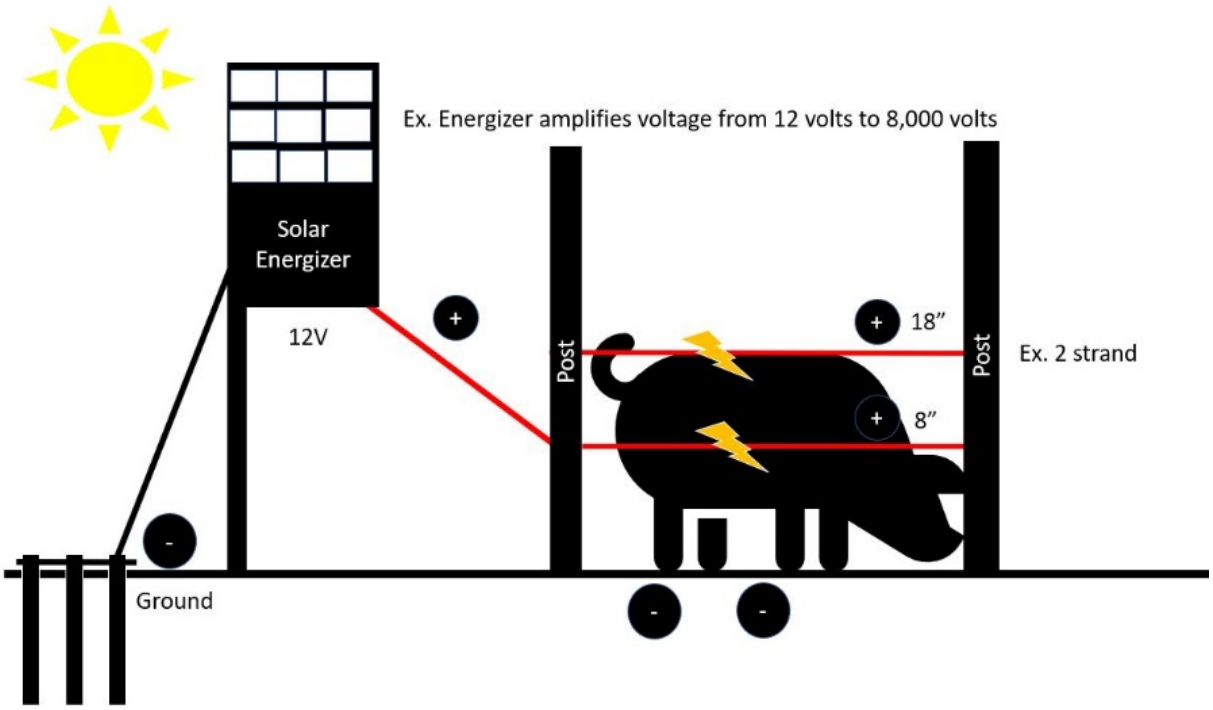

Figure 12. Reidy et al. (20008) found that the 2 strand polywire electrical fence reduced pig crossings by 50% and damage when compared with controls.

Lavelle et al. (2011) evaluated 5 fence designs: 1) electrified polywire, 2) electrified netting, 3) polypropylene mesh, 4) hog panels, and 5) woven-wire mesh. Voltage ranged from 9-10 kilovolts (kV) for the various fence types. Feral pigs were able to escape all fence types except for the 0.86-meter non-electrical hog panels (Oklahoma Steel and Wire Company Inc. Madill, OK). Vertical wires were spaced 8 inches apart. Four horizontal wires were spaced 2 inches apart from the ground up, two wires were spaced three inches apart, one wire was spaced four inches apart, two wires were spaced five inches apart and the last top wire was spaced six inches from the last wire. The study recommended utilizing a higher hog panel with a height of 1.3 meter or more for greater success. Similarly, Hone and Atkinson (1983) evaluated 8 different fence systems and found the 8 x 15 cm welded wire fence was the only design to fully exclude feral pigs. Shipping specialized fencing into Hawaii may require added freight and shipping charges.

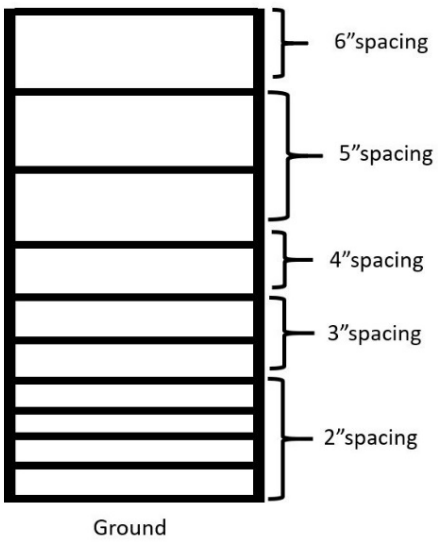

Figure 13. Wire distances from the ground used in the Lavelle et al. (2011 study.

Summary

Wild pigs can learn to adapt to single control management strategies, thus encouraging the use of multiple techniques (Richardson et al. 1997 & West 2009). Management of wild animals in commercial production systems requires an integrated pest management approach for long term sustainability, such as trapping, fencing, netting, noise, light, electricity, hunting (may require permitting and authorizations). There are currently no toxicants or poisons registered for use on feral pigs in the United States (Littauer, 1993, Mapston, 1999).

Illustrations by J. Sugano and A. Taniguchi

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