Technical Note
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Animal Production Litter Systems

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Introduction

Litter systems are an approach to hygienic, integrated animal production in which animals are raised in an enclosed space on a floor of organic bedding. Systems with thick bedding material are sometimes called ***deep litter*** systems. Litter systems allow you to prioritize animal health by providing conditions like those in animals' natural environments. Litter systems also help capture animal waste and convert it to usable forms for crop production.

Animals can be kept on a litter system for part or all of the production cycle depending on the farmer's context. These systems do not produce as much as industrial systems but can be more profitable for small-scale farmers by reducing both risks and costs. ECHO is aware of litter systems for pigs, rabbits, poultry, and ruminants. Benefits and tradeoffs of litter systems are detailed in table 1.

Table 1. Benefits and tradeoffs of litter systems.

Benefits	Tradeoffs
Low building costs	Sourcing litter material, especially in urban or arid areas, can be challenging
Low operational costs	
Reduced water-borne diseases	Modern fast-growing breeds no longer possess the strength or instinct to turn litter. Raising these breeds requires additional work to turn the litter
Little to no smell or flies	
Less time spent cleaning enclosures	
Ready-to-use compost created	Does not produce as much as high-input systems
Reduced risk	

Design components, enclosure size, and other factors of deep litter systems will depend on the animal you are producing. Standard aspects of litter systems include ventilation, sunlight, moisture control, predator control, and feeding greens.

Step-by-Step Enclosure Construction

Materials

- Bricks, stones, cement, or other impermeable material
- Siding material
    - Mesh wiring or fine netting like that used for mosquito nets (for poultry and rabbits)
    - Paneling made of wood, bamboo, or metal (for pigs and ruminants)
- Beams made of wood, bamboo, or metal
- Roofing material such as thatch, old billboards or feed bags, wood or any other available roofing material
- Construction nails or screws or lashing material

Construction

1. Locate a suitable site for the enclosure. The area should not flood during rainy times of the year and should be close to where people could hear an animal distress call and quickly come to check on animals. It should be close to a water source for ease of providing water for animals. If the site is not level, level the site before starting construction. Orient the structure north-to-south to take full advantage of available sunlight as the sun moves east-to-west. Sunlight provides warmth and keeps the litter from becoming too wet. Too much moisture limits oxygen, leading to flies and unpleasant odors. By the end of each day, at least part of the litter floor to be exposed to sunlight. Aspects of sunlight and shade are discussed in the subsequent steps below. For size considerations, see recommendations in table 2.
2. If you are building a deep litter system, in which the litter thickness will be 1 m or more, dig a hole for the litter. The depth of the hole should match the final litter thickness. If you are in a low-lying area and this hole would flood during rainy times of the year, the litter will need to be above the level of the ground. Figure 1 illustrates an above-ground deep litter area enclosed by 1-m-tall walls accessed by stairs.

Table 2. Recommended stocking densities for various adult animals. Densities can be greater when animals are young.

Animal	Density (no. animals per m^2)
Chickens	4.0-5.0
Turkeys	1.0-2.0 (FAS, 2020)
Pigs	1.0-1.15 (Tancho, 2013)
Rabbits	0.5-1.0 (Niles, 2009)
Goats	0.2-0.33 (Szekely, 2010)
Cattle	0.094-0.125 (AFRC, 2021)

Figure 1. Deep litter enclosure at ECHO North America RIC. *Source:* Chris Serville

3. Next, mark the four corners of the enclosure building and erect the posts (corner and support), making sure that the posts are square to each other. Posts should be anchored in the ground with at least 1/4 to 1/3 of the total length underground. If site soil is sandy, add rocks, cement, or other material into the post holes to stabilize the posts. Posts should extend high enough so that the roof they support (explained in step 4) will be high enough to allow workers to enter the enclosure and work with the litter, feeding and watering systems, and animals. Typically, this means that the posts should be 1.5 to 2 m above the litter level.
4. Construct the roof of the enclosure. The roof should slant slightly from the peak down to the edges so that water runs off the sides of the roof. If you are in a context where rainfall is not constant, consider leaving an opening in the roof, for sunlight and ventilation, on one side near the peak (Figure 2).

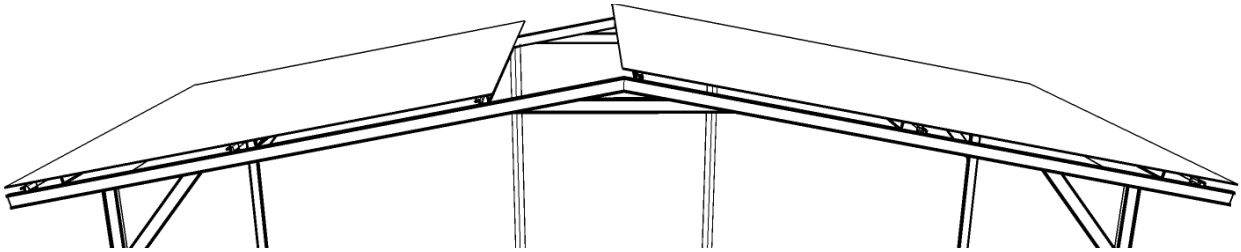


Figure 2. Gap in roof on one side of peak to help with air flow and allow sunlight in. *Source:* Noah Elhardt

Ventilation happens as hot air escapes through the gap, creating a convection current that draws in fresh air from the sides even when there is no wind. If you choose to include this opening, orient your coop so that, by sunset each day, the entire coop floor will have received sunlight at some point. If you are in a rainforest or lowland biogeographical region, an opening may allow too much water into the system. An alternative way to add a gap is to make one wall of the enclosure higher than the opposite wall and create a less steep slope on that side of the roof peak to leave a gap at the top. This will increase the air flow through convection in the enclosure.

5. Build the walls of the enclosure. Both animals and the litter benefit from a continuous supply of cool, fresh air. Enclosure walls should be made to maximize ventilation. Make enclosure walls out of wire mesh or another material that maximizes airflow while keeping animals safe from predators.

Figure 3. Brick perimeter at base of enclosure and perches. *Source:* Chris Serville

For each animal, recommended wall heights differ. For rabbits elevated off the ground in cages, walls are not necessary but can help with predator control. For poultry or rabbits not elevated, the walls should be 30-60 cm on all sides (Figure 3). For pigs, the hole or enclosure walls should be 1 m high to contain the deep litter (Tancho, 2013). Make sure there are no gaps in the wall that snakes, rodents, or other small predators could enter the enclosure through. For ruminants, an impermeable wall is not necessary, only

paneling or fencing to keep livestock contained and exclude canines or felines in the area.

To reduce the labor required to remove litter, some designs include ways to remove a portion of or an entire side of the enclosure so that a machine can easily scrape the litter to remove it when ready. ECHO staff in Florida accomplished this by building a section of the litter wall with stacked, removeable ferrocement panels held in place with guard rails (Figure 4). If using mortar to join blocks/stones, build one layer at a time, allowing the previous layer to dry enough to support the next layer of material.

6. Add a shade structure if necessary. If your enclosure is small, the morning or evening sun streaming through the sides of the enclosure might cover the entire enclosure. If this is the case, you may want to add a shade structure similar to the one shown in figure 5 to provide animals with shade in part of the space.
7. Add whatever mesh or panel material may be necessary. When the litter is fully made and ready, animals should still be contained. This means if you are raising pigs in a deep litter, you will have to add paneling above the 1 m wall or hole to contain pigs on the litter (Figure 6). For poultry, wire mesh should be added from the wall to the ceiling to contain birds. Mesh is not required for rabbits in cages but mosquito netting can help control mosquito-borne diseases like myxoma virus. [1] Paneling can be made of wire material or wood. If you cannot have well-vented sides to get extra air flow, install a fan (electric or solar powered).

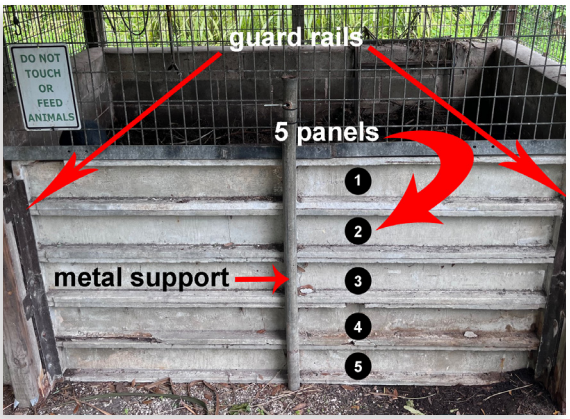


Figure 4. Removable ferrocement panels, held in place by guard rails and a metal support pole, to allow for removal of litter from a deep-litter pig enclosure. *Source:* Tim Motis

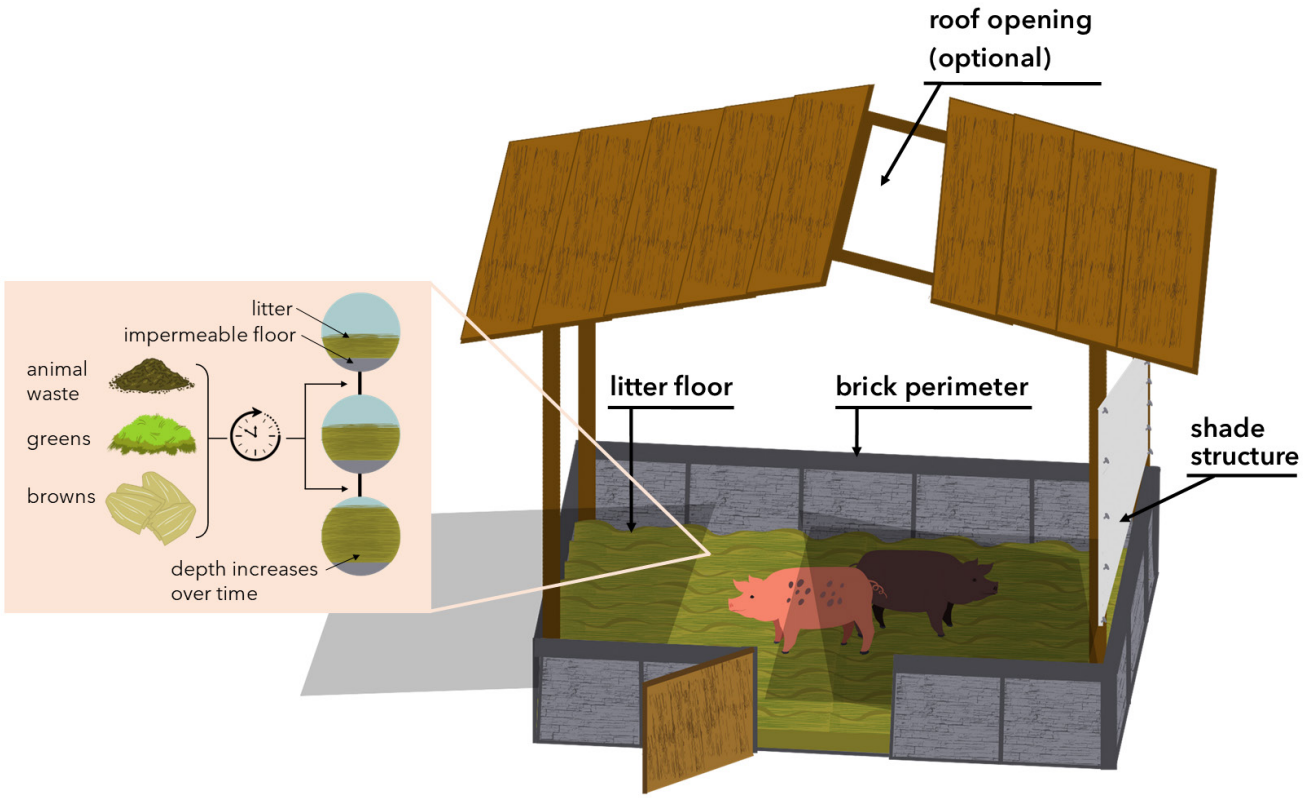
Figure 5. Shade structure made from bamboo. This is often a good idea on one or two sides in these small coops to ensure shade availability in the mornings and late afternoons, and/or for wind protection. *Source:* Noah Elhardt

Figure 6. Metal paneling to contain pigs when litter area is full. *Source:* ECHO Staff

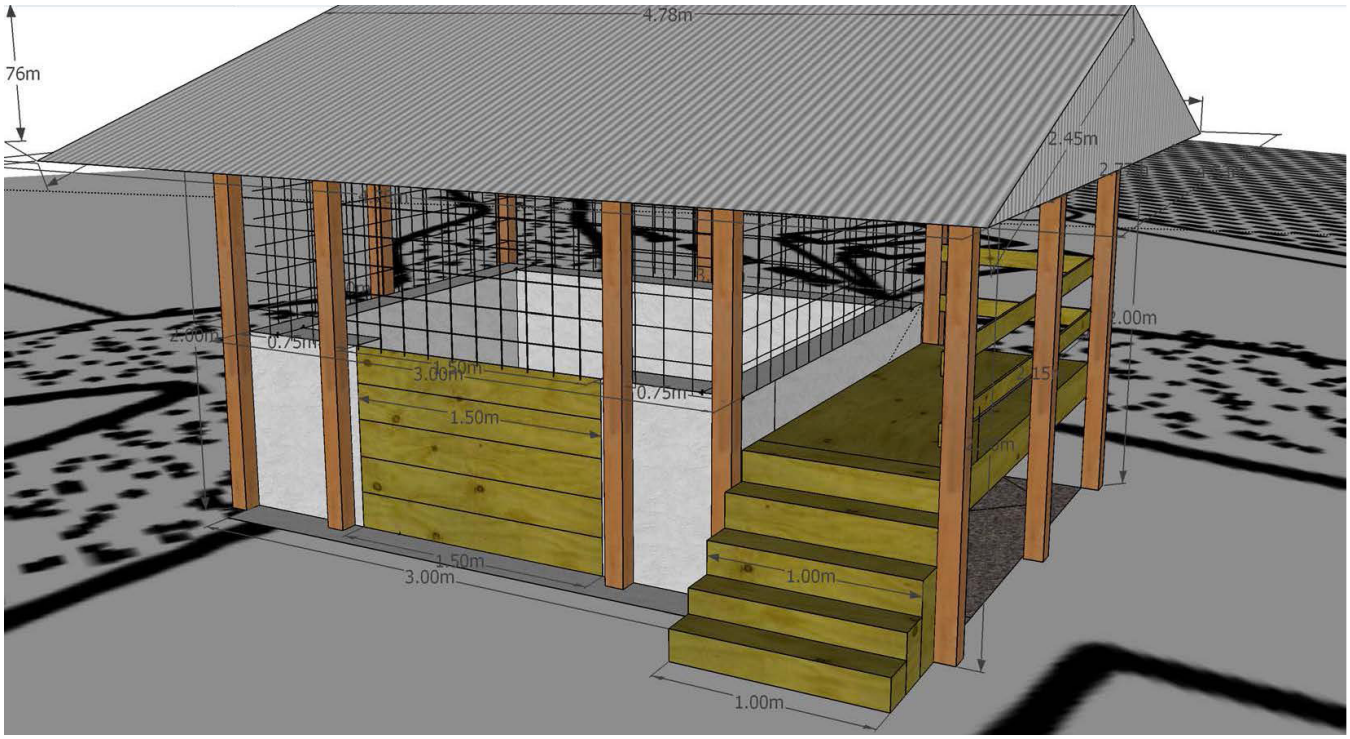
[1] This virus is found in Europe, the Americas, and Australia (MacLachlan and Dubovi, 2016). It is not a concern in Asia or Africa.

Example Diagrams

Pigs

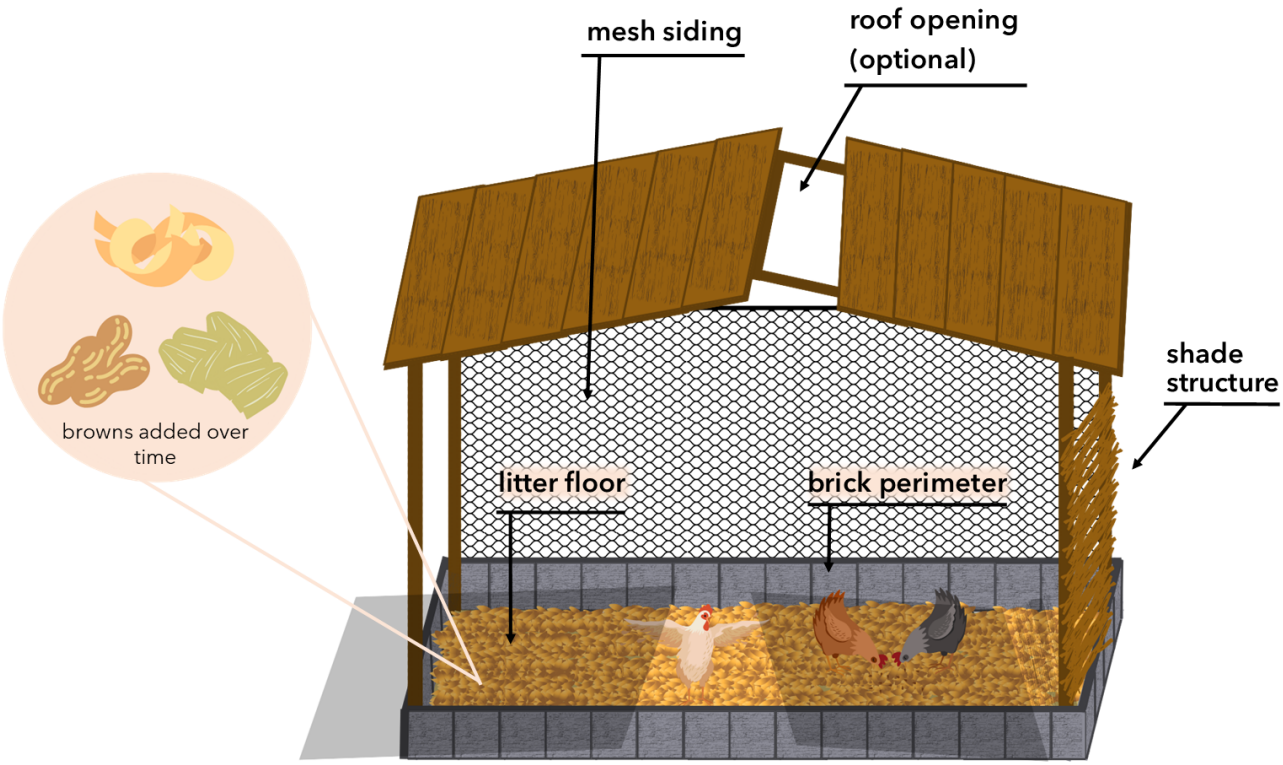


Source: Weslee Green, created using Canva



Source: ECHO Staff

Chickens



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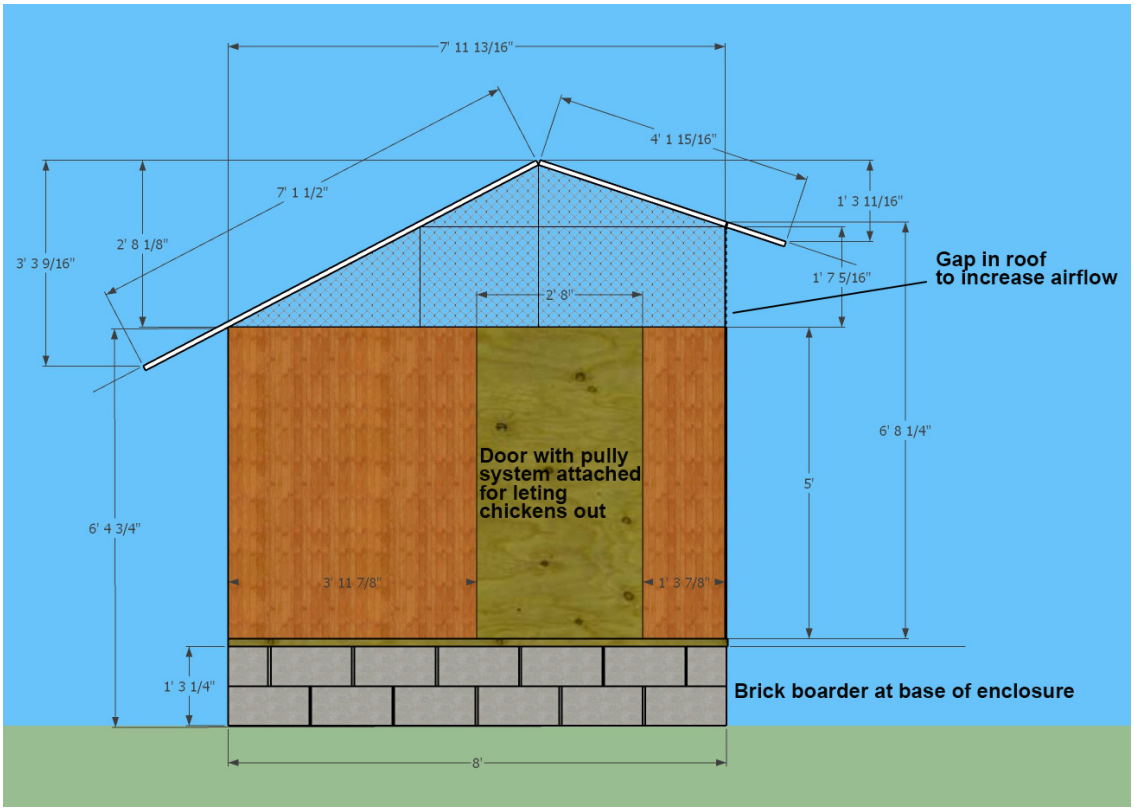
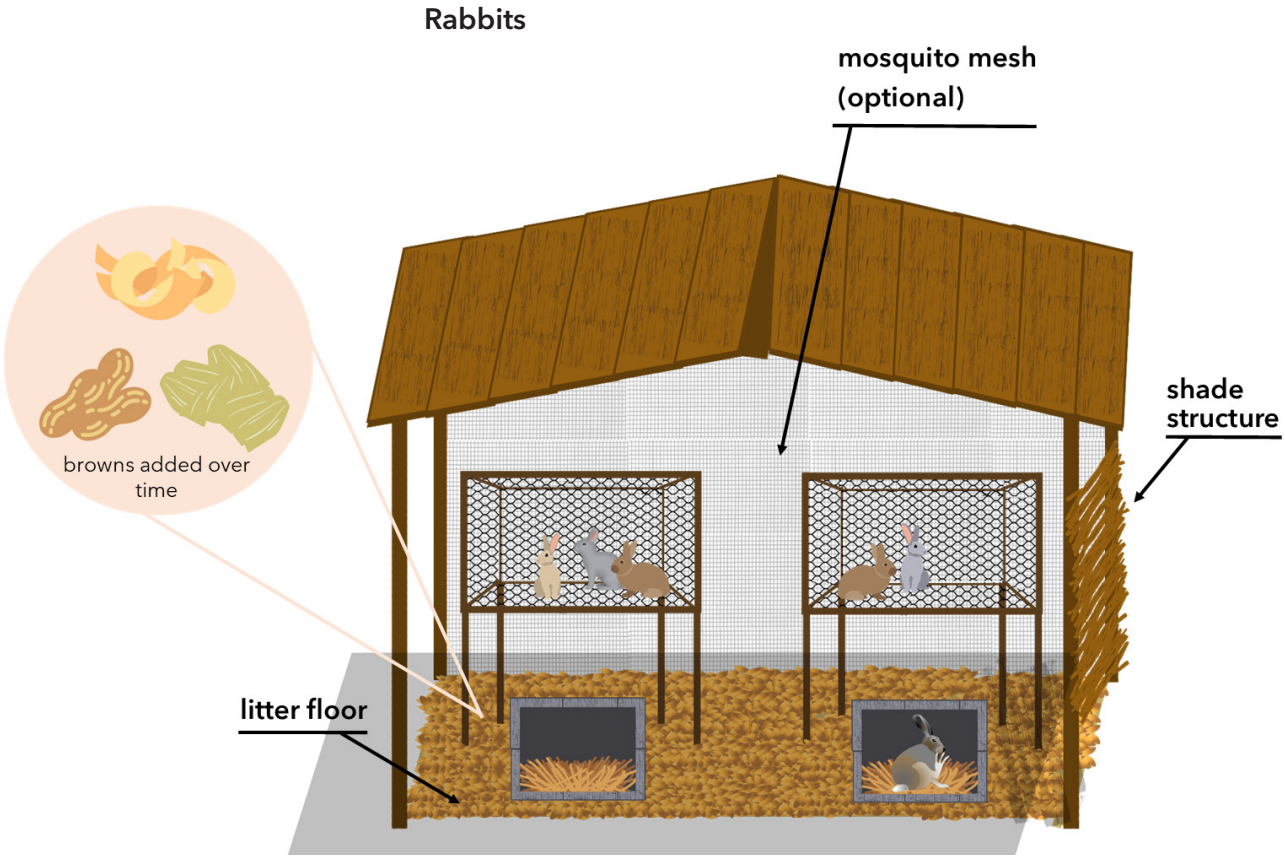


Measurements in feet (') and inches ("). *Source:* ECHO Staff



Source: Weslee Green, created using Canva

Tips for successful management of animals and litter

Predator control

Protect animals from predators especially when animals are confined in enclosures and cannot escape a predator attack. Common predators for rabbits and poultry are rodents, snakes, small mammals, and birds of prey. Common predators for pigs and ruminants are large felines or canines. Impermeable walls help with predator control and are specified by animal in the construction section of this article. Some designs include a buried section of mesh wiring that extends 60 to 90 cm out from the base of each wall to keep digging predators from entering the enclosure. Paneling that excludes large mammals is used for pig and ruminant enclosures.

Figure 7. A litter floor made of wood chips, peanut shells, and millet chaff.
Source: Noah Elhardt

Litter options and management

The litter at the bottom of the enclosure should be at least 15 cm deep (poultry) and up to 1 m deep (pigs). Inadequate litter will become wet, compacted, and smell bad. Select a litter that is loose, dry, and high in carbon. It will combine with the animal excrement to form a living compost. Options for litter materials include dried leaves, rice hulls, crushed peanut shells, crop residue, grasses, and sawdust (Figure 7).

Some recommend gathering and placing all the litter inside the enclosure before putting pigs on it. Tancho (2013) recommends a 1 m deep litter of mixed sawdust, soil, and sea salt at a ratio of 100:10:0.3. ECHO network members have recommended layers of biochar (15-30 cm), larger then smaller sticks (60-90 cm; the larger sticks are added to prevent the pigs from digging beyond the bottom of the litter floor), green material such as banana leaves (60-90 cm), followed by fine carbon-rich material like rice hulls or sawdust which should be the top layer (remainder of 1 m litter). Experience at ECHO has also shown that it is possible to add dry, brown material over time as the pigs grow instead of entirely at the beginning. Dry, brown materials used by ECHO have included sawdust, coffee chaff, and rice hulls. Biochar is added if available. Green material is added in the form of plant material fed to the animals.

Staff at the ECHO North America RIC built the first deep litter with these layers but found that the pigs could not root down through the layers to thoroughly mix them. The resulting compost was not decomposed well and was not uniform in texture. It had to be removed, mixed, and added back to the deep litter system over time to become usable compost.

A well-established litter contains microbes which rapidly break down manure and outcompete disease organisms. Healthy litter smells like the healthy soil of a forest floor. To speed up the formation of a diverse and active microbial community in your litter, you can inoculate it with Indigenous Microorganisms (IMO) or Effective Microorganisms (EM). IMO are cultured using inexpensive local materials such as bran or cooked rice. Apply IMO or EM liquid at a dilution of 1:500 when first establishing a litter, or if problems or smells arise later (Tancho, 2013). For more information about IMO, view ECHO's resource about IMO.

The litter floor of the enclosure should be moist but not wet (60% moisture or less). This moisture range helps prevent the spread of water-borne diseases such as botulism which affects poultry. Moist, but not wet litter also maintains microbial processes that break down animal waste aerobically, which reduces the smell of animal systems. If conditions get too wet, the anaerobic decomposition of animal waste will create a rancid smell. Drier litter provides space for some animals to perform natural behaviors such as dust baths (chickens). Below are some troubleshooting steps for litter management:

- If the litter pools water, it is too wet. Add more dry litter material.
- If the litter smells rancid but is dry, add more IMO or EM to the litter and lower portion of the enclosure walls where it touches the litter.
- If the litter smells rancid and is wet, add more dry litter material.
- If the litter smells good but is wet and dark in color, it may be time to harvest the litter for use as compost.
- If you are in a dry climate, you may occasionally need to water the litter to keep the decomposition process going.

Poultry and pigs aerate and mix the litter by scratching or rooting, natural behaviors when looking for food. Mixing behaviors helps reduce smell and more evenly disperse the moisture of the entire litter. Commercial breeds no longer possess the strength or instinct to turn litter. Raising these breeds requires additional work to turn the litter.

Compost considerations

After 3 to 6 months, shallow litter materials turn into compost and can be used directly on crops or stored for later use (Figure 8). Deep litter for pigs becomes useable compost after 4 months (one generation of pigs); however, the nutrient composition of the compost will be higher after 8 months (two generations of pigs) (Tancho, 2013). ECHO Florida staff sent pig deep litter compost samples for nutrient analysis from 2018-2020. Organic matter of the compost was 9 to 21% (high). Phosphorus content ranged from 1336 to2434 kg/ha and potassium content ranged from 4789 to 11212 kg/ha (both very high). Lastly, pH ranged from 8.2 to 9.0 which is alkaline, mainly a concern if you are wanting to apply the compost to a soil that is already alkaline. Used in moderation, plants at ECHO have not shown any adverse effects when amended with the high pH compost.

Figure 8. Compost extracted from the pig deep litter system and stored at a holding bay. *Source:* Robert Walle

Feeding Livestock

An important part of success for any animal system is a healthy diet for the livestock. When animals eat well, they have the energy and health to fight off diseases and to produce quality products (meat, eggs, milk, and offspring). Greens are an important part of animals' natural diet. Options for greens include grass, sweet potato leaves, moringa, katuk, chaya, weeds, leguminous tree leaves, and much more. For information about rabbit feeding, see Niles (2009). At the Beersheba Project, staff feed 30-40 g of greens per chicken per day. For more information about incorporating greens and other local options into chicken feed, see "Cafeteria Feeding" of Chickens (http://edn.link/yf6mmc) from *EDN* 97 (Peckham, 2007).

Natural farming practices that often accompany deep litter systems include feeding pigs a homemade banana stalk silage (http://edn.link/dfy2ay). ECHO Asia compared this on-farm feed with commercial feeds with findings summarized in *ECHO Research Note* Volume 2, Issue 3: Making on-farm pig feed: Farm-generated formulas vs. commercial feeds (http://edn.link/k6xg72). Feed ruminants whatever crop residues are in excess of what farmers want to leave in the field as well as plant material from forage species. Tropical forages for the smallholder farm are overviewed in *ECHO Technical Note* 28: Forages (http://edn.link/tn28). Plant forages or crops used to feed animals close to the enclosure to reduce labor and time needed to feed greens.

Figure 9. Cattle litter system in Guatemala. *Source:* Robert Walle

Optimize the system based on the animal

Ruminants

In Quetzaltenango, Guatemala farmers put cattle into a deep litter system during the dry season (Figure 9). The litter consists of corn stover (in this case) added over the

dry season. Farmers feed cows a mix of feed concentration with vitamins and mineral salt in stalls. Corn stover is stored above the pen and fed over time. The cows return to pasture when enough fresh grass grows. Farmers then apply the collected manure/litter to crops.

Pigs

Pigs will typically use one part of the enclosure as a bathroom. You may need to go into the enclosure periodically to move manure around more evenly. Alternatively, you can put a large object such as a barrel cut lengthwise over the bathroom area until the pigs have selected a new bathroom spot of the enclosure. Use what works best for your system.

Pigs like to wallow (take baths in mud), which helps keep them cool. Consider incorporating a small space, perhaps in a corner of the enclosure, for the pigs to wallow and drink. Surround the wallowing space with walls that will keep water out of the litter area and that are short enough for the pigs to access from other areas of the enclosure.

Tancho (2013) recommends watering and feeding in separate spaces. This minimizes crowding and, given pigs' tendency to overturn watering containers, helps prevent uneven moisture of the litter. If using a watering trough, consider placing it outside of the litter area where they can drink by pushing their heads through a grate to access the water. Another watering option to consider, if available, are valves –that function as water nipples – on the end of a garden hose suspended from the rafters (Figure 10), allowing pigs to access water on demand without spillage.

Figure 10. Water nipple apparatus (circled) supplied with water via a hose and suspended from the rafters of a deep litter pig enclosure. *Source:* Tim Motis

Poultry

Chickens, turkeys, and doves can be produced at high densities and therefore are one of the most profitable for smallholders to use in litter systems. Litter systems are not appropriate for ducks or geese because the systems are too dry. Ducks need ample amounts of standing water to dabble while eating and to wash their eyes frequently. Include perches inside your enclosure.

Figure 11. Rabbit hutches elevated off the ground with litter area directly under cages. Animal waste and unwanted forage drops from the gaps in the cage floor and is added to the litter. *Source:* ECHO Staff

Rabbits

Rabbits are more particular than the other animals listed. They do not thrive under messy conditions with feed material or contaminated litter around. ECHO community members around the tropics have found that rabbits do much better when elevated off the ground and suspended in cages over the litter (Figure 11). For more information about options and dimensions for rabbit cage construction, see Niles (2009). Male rabbits need to stay cool to remain fertile. In hot conditions, build brick, concrete, or stone dens for breeding bucks on the floor of your rabbit area.

Conclusion

Litter systems described here highlight the use of simple, creative designs to harness the benefits of naturally occurring resources – sunlight, air, and microbes– for long-term success in raising healthy animals. Combine elements of structural design with healthy feed for the best outcomes.

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