

10. PEST CONTROL

10.1. Introduction

Portugal is located in Southwestern Europe, in a region conducive to the presence of animal species that act as mechanical or biological vectors for the transmission of pathogenic agents. Diseases transmitted by these vectors are a concern, and in this context, measures must be implemented to reduce the risk of transmission.

10.2. Arthropods

- Mosquitoes:
 - *Culex* spp.: vectors of agents associated with canine dirofilariasis, West Nile Fever, among others;
 - *Aedes* spp.: vectors of agents associated with canine dirofilariasis, Chikungunya, dengue, and equine encephalitis;
 - Mosquitoes (Family Culicidae): involved in the transmission of Bluetongue, Schmallenberg disease, Akabane disease, African Horse Sickness, etc.
- Flies:
 - Horse flies (Family Tabanidae): involved in the transmission of viral diseases such as Equine Infectious Anemia, Classical Swine Fever, and Vesicular Stomatitis; parasitic diseases such as Trypanosomiasis and Besnoitiosis; and bacterial diseases such as Anthrax, Bovine Anaplasmosis, Lyme disease, etc.;
 - Common house flies: mechanical vectors for more than 100 pathogenic agents causing disease in animals and/or humans, for example *Bacillus anthracis*, *Escherichia coli*, *Vibrio cholerae*, etc.;
 - Face fly (*Musca autumnalis*): vectors of *Moraxella bovis*, associated with bovine conjunctivitis and keratitis; *Corynebacterium pyogenes*, which causes abscesses with pus in domestic animals; and intermediate hosts of *Thelazia* spp. and *Parafilaria* spp., associated with parasitic ocular infection and subcutaneous lesions, respectively;
 - Horn fly (*Haematobia irritans*): not described as vectors of disease but affect animal welfare;
- Sand fly (*Phlebotomus* spp.): vector of canine leishmaniasis.
- Ticks:
 - The three most common tick species in Portugal are *Ixodes ricinus*, *Dermacentor reticulatus*, and *Rhipicephalus sanguineus*, which may transmit Lyme disease, Babesiosis, and Ehrlichiosis.
- Fleas:
 - Vectors of bacterial species such as *Bartonella henselae* and *Mycoplasma haemofelis*, which cause Cat Scratch Disease in humans and Feline Infectious Anemia, respectively.
- Lice:
 - Host-specific. Vectors involved in the transmission of pathogens such as Swine Pox virus, *Anaplasma* spp., and *Trichophyton verrucosum* in cattle.
- Mites



- Feed on skin debris and may cause various diseases such as sarcoptic mange, otitis, and lesions in different parts of the animal's body.

10.2.1. Control and Monitoring of Arthropods

- Preventing flying insects from entering animal facilities is crucial, especially isolation units housing patients with infectious and contagious diseases, and contact with potential hosts should be minimized.
- Non-flying arthropods are spread via infested hosts, accidental transport by humans, and sharing of materials/equipment between animals.
- The best approach for arthropod/vector control consists of combining several methods through an Integrated Vector Management Program (IVMP).

10.2.1.1. Capture of Adult Flying Insects

- Capturing adult flying insects contributes to:
 - Reduction of insect populations
 - Validation of control measures
 - Detection of new species
 - Identification of breeding sites
- Traps adapted to target species must be used.

10.2.1.2. Physical Measures to be Implemented for Arthropod Control

- Facility doors must always remain closed.
- Sticky insect traps should be placed in strategic locations, namely in the Equine Isolation Unit and in Bars/Cafeterias.
- Screens (galvanized mesh) with mesh sizes appropriate to target insects should be installed in strategic locations.
- In the Equine Isolation Unit (biosafety level 4), several levels of physical control exist to reduce the entry/exit of flying insects:
 - Closed windows
 - Double doors
 - Animal anterooms delimited by two gates
 - Installation of two screen layers between the exhaust pathway (HEPA filters) and the ventilation pathway
 - HEPA filters



10.2.2. Environmental Control of Habitats and Breeding Sites

- Main breeding sites of flying insects:
 - Mosquitoes: *Culex* spp.: stagnant water; *Aedes* spp.: tree holes, buckets, or other water storage containers
 - Mosquitoes (Family Culicidae): moist organic matter such as decomposing leaves and any animal excrement
 - Flies: wet organic matter; larvae feed on a wide variety of materials (blood, meat, carcasses, excrement, decomposing plant matter)
 - House flies and face flies: fecal matter (e.g., manure storage containers)
 - Sand flies: flower beds, green waste, and epiphytes
 - Mosquito control: egg-laying sites within a 1.5–2 km radius of facilities should be controlled. Mosquitoes require stagnant water for more than 96 hours to lay eggs, so mapping risk areas (e.g., resident cattle park) is essential
 - Black flies (Genus *Simulium*): lay eggs in oxygen-rich running river water
 - Ticks: control grazing areas (two paddocks: horses and dog park)
- Green area maintenance must be managed sustainably to limit negative impacts on biodiversity.

10.2.3. Integrated Vector Management Program (IVMP)

- Involves ecosystem-based strategic cooperation, focusing on long-term vector population control through combining different techniques:
 - Species surveillance in a given location
 - Physical control
 - Training: raising awareness about breeding habitats and how these can be reduced/eliminated
- Applicable measures for different FMV facilities are detailed below

10.2.3.1. Production Animal Facilities (Equines and Ruminants)

- Specific prevention and control measures for these facilities are listed in the tables below.
- Physical control of flying insects with electric insect killers, screens, and window traps is essential. Doors must be kept closed, especially in facilities housing animals.
- Regarding ectoparasites, infected and non-infected animals must be separated. Limiting animal movement between facilities helps reduce ectoparasite transfer.
- Chemical control of adult flies is recommended if populations reach harmful levels. Residual insecticides such as pyrethroids may be sprayed in fly resting sites (walls and structures). However, this should be avoided whenever possible to prevent resistance development.
- Management of Culicidae breeding sites is often difficult. Insecticides or repellents applied directly to animals provide some protection but are not highly effective in reducing Bluetongue virus transmission during epidemics.



- Keeping animals indoors reduces bites from resistant mosquitoes.

10.2.3.2. Isolation of Facilities

- Installation of screens/filters reduces insect presence.
- Screens/filters must be inspected regularly for damage and cleaned monthly.
- Smaller mesh sizes in dusty environments may clog pores, reducing ventilation.
- Various methods may be used to control ectoparasites and ticks in the environment and herds.
- In general, whenever an animal enters the facility, it must undergo quarantine, inspection, and insecticide treatment before contacting other animals.
- Sheep-specific measures:
 - Shearing ewes before lambing prevents the spread of *Melophagus ovinus*, an external parasite that attaches to wool and feeds on blood. It also prevents fly strike (larval infestation of wounds).
 - Shearing wool soiled with urine and/or feces prevents fly attack.
 - Scheduling lambing before spring is recommended since flies are less abundant at that time.

10.2.3.3. Small Animal Facilities

Specific prevention and control measures for the Companion Animal Hospital are detailed in the following tables.



Table 10
Arthropod control measures in production animal facilities

	Mosquitoes	Culicoides	Horseflies (Tabanids)	Flies*	Black flies
Physical measures					
Keep doors closed at all times	×	×	×	×	×
Window screens/mesh – mesh size (≥ 1.5 mm)** (regular maintenance)	×		×	×	
Window screens/mesh – mesh size < 1 mm** (regular maintenance)		×			×
Capture using electric fly-killing devices				×	
Pasture trapping (shelter to reduce light exposure)					×
Chemical measures					
Organophosphate compounds	×				
Carbamates	×				
Pyrethroids	×	×	×	×	×
Diethyltoluamide (DEET)			×		
Insecticide application on adult animals	×	×	×	×	×
Environmental insecticide application (e.g., sprays)	×			×	×
Environmental measures					
Avoid standing water and water accumulation	×				
Control humidity		×	×	×	
Reduce/remove unwanted emergent vegetation	×				
Limit feed access: store feed in closed rooms				×	
Protect hay				×	
Strict hygiene (remove waste such as feces)		×		×	
Avoid accumulation of organic debris		×		×	
Remove debris daily (e.g., spilled feed, dry vegetation, leaves)				×	
Remove debris near water sources					×
Waste containers					
Dispose of and clean twice per week	×			×	
Keep waste containers covered with lids	×			×	
Drainage system	×				
Rain gutters – periodic inspection and cleaning (leaves/debris)	×				
Repair to ensure proper drainage	×				
Keep ditch drainage free of vegetation and debris	×				
Drains with fine mesh kept free of water and debris	×				
Manure/feces					
Manure storage areas must be kept dry				×	
Daily removal				×	
Avoid fecal accumulation on walls/bars and floors				×	
Turn manure once per week to prevent hatching				×	

* Flies: common houseflies (*Musca domestica*), stable flies (*Stomoxys calcitrans*), face flies (*Musca autumnalis*), and horn flies (*Haematobia irritans*)

Table 11
Arthropod control measures in companion animal facilities

Measures	Mosquitoes	Houseflies	Sand flies
PHYSICAL MEASURES			
Keep doors closed at all times	×	×	×
Window screens/nets – mesh size ≥ 1.5 mm* (regular maintenance)	×	×	×
Window screens/nets – mesh size < 1 mm* (regular maintenance)			×
Capture using electric fly-killing devices		×	
CHEMICAL CONTROL			
Organophosphate compounds	×		
Carbamates	×		
Pyrethroids	×	×	×
Application of insecticides to adult animals			×
Application of insecticides in the environment (e.g., sprays)	×	×	×
ENVIRONMENTAL CONTROL			
Avoid presence and accumulation of standing water	×		
Control humidity		×	
Reduce/eliminate vegetation	×		×
Waste containers			
Dispose of and clean weekly	×	×	×
Keep waste in closed bins/containers	×	×	×
Drainage system			
Rain gutters – periodic inspection and cleaning (leaves/debris)	×		
Rain gutters – repair and ensure proper drainage	×		
Grates – keep drainage ditches free of excessive vegetation and debris	×		
Grates – small-mesh drains must be kept free of water and debris	×		
Avoid accumulation of organic debris (regular inspection and removal)		×	×
Remove organic waste weekly (e.g., spilled food, dry vegetation, leaves)		×	
Remove pet feces daily		×	
Promptly place small animal carcasses in yellow containers (collected and refrigerated until final disposal)		×	
Seal cracks and crevices in walls, ceilings, floors			×
Clean outdoor flooring areas			×
Destroy rodent habitats (hosts of insects)			×
Keep dogs indoors at dawn and dusk to minimize the risk of leishmaniosis			×

Table 12
Tick and permanent ectoparasite control measures (companion and production animals)

Measures	Ticks	Lice	Mites	Fleas
PHYSICAL CONTROL				
Separate / limit contact between healthy and infested animals		×	×	×
Hospitalization		×	×	
Avoid sharing cages	×	×	×	×
Companion animals: avoid marking territory during dog walks outside the clinic	×			
Limit animal movement between facilities (to reduce transfer of ticks and ectoparasites)	×	×	×	×
Regularly check patients – daily marking for inspection and removal if necessary	×			
Perform daily cleaning of rooms and bedding				×
Clipping/shearing if necessary (severe infestation)		×	×	×
CHEMICAL CONTROL				
Application of chemical agents for treatment in animals (internal deworming)	×	×	×	×
Application of ivermectin or similar parasiticides	×	×	×	
Companion animals: treatment with insecticides	×	×	×	×
ENVIRONMENTAL CONTROL				
Environmental management				
Reduce tick presence around buildings	×			
Annually trim trees and shrubs around buildings	×			
Regularly mow grass and remove vegetation around buildings	×			
Remove leaf litter	×			
Install fencing in facilities	×			
Manage rodent-friendly habitats (control vegetation around outdoor storage, stone walls, and small openings)	×			
Control rodents to minimize contact with vectors	×			×

10.3. Rodents

- The following may be found on FMV premises:
 - House mouse (*Mus musculus*) – Nests inside and around buildings, omnivorous, prefers stored food.
 - Black rat (*Rattus rattus*) – Prefers grains and fruit and is an agile climber.
 - Brown rat (*Rattus norvegicus*) – Omnivorous, nests below surfaces, and is a strong swimmer.
 - Wood mouse (*Apodemus sylvaticus*) – Lives in wooded areas, around houses, ruins, rocky areas, and parks. Avoids open pasture and is omnivorous.
 - Common vole (*Microtus arvalis*) – Lives in open areas and dry pastures with low vegetation, cultivated fields, and gardens.
 - Bank vole (*Myodes glareolus*) – Lives in deciduous forests, hedgerows, woodlands, and vegetated ditches. Omnivorous.
 - Rodents require water daily and are attracted to animal feed, bedding, and animal waste.



10.3.1. Diseases Associated with Rodents

- Rodents can transmit and spread pathogenic agents. They may carry various pathogens and are a potential source of infection for humans and animals:
 - Bacteria: *Campylobacter* spp., *Salmonella* spp., *Yersinia pestis*, *Pasteurella* spp., *Leptospira* spp., *Brachyspira hyodysenteriae*, *Rickettsia* spp., *Escherichia coli*, *Listeria* spp., *Mycobacterium* spp., *Brucella* spp.
 - Viruses: Hepatitis E virus, encephalomyocarditis virus, porcine circovirus type 2, rabies virus, hantaviruses.
 - Parasites: *Trichinella* spp., *Toxoplasma* spp., *Cryptosporidium parvum*.
- Rodents may contaminate food with feces and urine.
- They can damage feed, equipment, and materials, and may destroy insulation materials, electrical wiring, and pipes.
- Rodents can also be a source of stress for animals due to their nocturnal activity.

10.3.3. Signs of Rodent Infestation

- Characteristic sounds: gnawing noises, squeaks, and climbing sounds.
- Presence of droppings: along walls, behind objects, or near feeders. Rat droppings are dark, bean-shaped (about 10–12 mm long and up to 5 mm in diameter). Mouse droppings are dark, about 4 mm long and much thinner (≈ 1 mm in diameter).
- Direct observation of rodents moving, often associated with dust-free areas along walls.
- Mouse or rat burrows.
- Gnaw marks: chewed wood, torn grain sacks.
- Grease marks: a greasy film on pipes and frequently used surfaces (typical of infestations lasting more than two years).
- Strong, characteristic odor, especially with large populations.

10.3.4. Prevention of Rodent Infestation

- Preventive measures must limit rodent entry and access to animal facilities while avoiding conditions that favor nesting, feeding, and reproduction.
- Avoid outdoor hiding places:
 - Keep building surroundings clean and uncluttered;
 - Avoid accumulation of materials, weeds, or waste near floors and against walls.
- Limit rodent entry:
 - Keep doors permanently closed; they should fit tightly to the floor ($\text{gap} \leq 0.6$ cm).
 - Seal openings > 0.6 cm with rodent-resistant materials (do not use wood, rubber, or plastic), paying special attention to gaps around pipes, cables, and other openings.
 - Protect vulnerable corners with metal plates or mesh.
 - Create a gravel barrier at least 1 meter wide around buildings.
 - Carry out an annual building inspection, focusing on door gaps, broken windows, water connections, and holes near feeding areas.
- Eliminate potential food sources:
 - Store feed in tightly sealed, rodent-proof bags or metal containers with lids.
 - Store only the minimum necessary quantity of feed and hay.
 - Clean feed storage areas weekly.



- Store hay and straw on pallets, off the ground.
- Clean up any feed spills immediately.
- Remove accessible water sources for rodents.
 - Waste storage and disposal:
- Immediately remove food waste, droppings, and other materials that may attract rodents.
- Animal carcasses must be disposed of according to regulatory procedures in appropriate locations.
- Take measures to reduce potential nesting and hiding sites.
- Equipment (refrigerators, washing machines) should be movable to allow cleaning underneath and behind.
- Feed bags should be stored on pallets, leaving free space around and underneath.

10.3.5. Rodent Control

- Combined control strategies should be adopted, including physical control (such as traps) and chemical control (such as properly authorized rodenticides applied by qualified professionals).
- Dead rodents must be collected using protective gloves to ensure safety and prevent contamination.
- The use of traps is recommended not only as a control method but also as a monitoring tool to assess rodent presence and activity in the facilities.

10.3.5.1. Physical Control

- Traps should be placed in strategic locations such as:
 - Areas frequently used by rodents (along walls, behind objects, in dark corners).
 - Feed storage areas (keeping a safe distance from the feed).
- Sensitive areas such as surgery rooms or wards with hospitalized patients must be avoided.
- To increase effectiveness, two traps should be placed in line to prevent rodents from jumping over them.
- Plastic traps should be used, as they are easier to clean and prevent odor buildup that may deter rodents.
- Mechanical snap traps should be avoided, as they may alarm animals and make rodents more cautious.
- The use of ultrasonic devices is strictly prohibited in animal facilities, as these devices may cause stress to patients.

10.3.5.2. Chemical Control

- The most commonly used rodenticides are anticoagulants, available as paraffin blocks, foam, gel, and other formulations. These are divided into:
 - First-generation anticoagulants – require repeated ingestion over several days;
 - Second-generation anticoagulants – effective after a single ingestion.
- Baits should be placed along rodent travel routes:
 - 1–2 meters between bait points for mice.
 - 7–10 meters for rats.
- Never place baits in areas accessible to patients.



- Rodents usually die 3–4 days after ingestion, away from the bait points, which reduces bait shyness (neophobia) and unpleasant odors.
- Always strictly follow the instructions on the product label.
- Baits must be fresh and palatable to ensure attractiveness.
- Unconsumed baits must be collected (using gloves) and discarded.
- Baits must be placed in appropriate bait stations, in locations inaccessible to people and non-target animals. Bait must be secured inside locked stations.
- For mice, install bait stations 5–7 days in advance to allow acceptance.
- Regular inspections must be carried out to check bait availability, remove rodent carcasses, and record bait disappearance or consumption.
- The best time for infestation control is when facilities are empty and free of food or feed residues, reducing alternative food sources.

10.4. Birds

- Bird species that pose a biosafety risk at FMV facilities, by entering or nesting in large-animal buildings, mainly include pigeons and swallows (*Hirundo rustica*, *Delichon urbicum*).
- Crows may also be problematic, particularly regarding the integrity of large-animal facilities.
- Swallows (family Hirundinidae) are a protected species; destroying them or removing nests is illegal, even outside the nesting season. Swallows build nests with mud and feed mainly on insects.
- Pigeons (*Columba livia* and *Columba palumbus*) feed on grains, seeds, urban waste, insects, bread, and other human-provided foods. They nest on eaves, beams, and building structures. Breeding may occur year-round, with peaks in spring and autumn. *Columba palumbus* is legally protected and may not be culled.
- The common blackbird (*Turdus merula*) may occasionally be observed near the facilities.

10.4.1. Problems Associated with Birds in Production Animal Facilities

- A presença de aves nas instalações destinadas a grandes animais pode originar vários tipos de Birds may consume feed and water intended for animals.
- Wild birds can carry and spread pathogens, contaminating feed, water, and surfaces.
- Pathogens associated with bird transmission include:
 - *Salmonella* spp.
 - *Escherichia coli*.
 - *Campylobacter* spp.
 - *Listeria monocytogenes*.
 - *Brachyspira hyodysenteriae*.
 - West Nile virus
- .- Intestinal parasites such as roundworms (*Ascaris*) and tapeworms (*Taenia* spp.).
- Bird droppings are corrosive and may damage equipment, metal surfaces, and vehicles, affecting infrastructure.
- Nests may obstruct drainage systems and gutters, leading to leaks and structural deterioration.
- Birds may damage thermal or acoustic insulation materials, compromising comfort and energy efficiency.



10.4.2. Measures to Prevent Birds in Production Animal Facilities

- Preventing bird entry and presence requires a combination of measures, including:

- Physical Barriers and Access Restriction

- Keep doors and windows closed or protected with suitable nets/mesh.
- Use durable plastic strip curtains in areas where doors cannot remain closed.
- Cover openings larger than 1.3 cm with metal mesh or materials that cannot be pecked (when applicable).
- Protect windows and openings with well-fitted metal mesh; promptly repair broken or poorly sealed windows.

- Control of Food and Water Sources

- Store feed in sealed metal containers in closed rooms.
- Immediately clean any spilled feed from containers and surrounding floors.
- Clean feeding areas daily.
- Eliminate access to water sources whenever possible.
- Avoid insect proliferation, as insects serve as food for some species (e.g., swallows).

- Reduction of Nesting and Roosting Sites

- Avoid structures that promote nesting, such as sheltered ledges, exposed beams, or areas difficult to clean.
- Install spikes or other deterrent systems to prevent perching, especially by pigeons.
- Consider controlled nest removal for pigeons, in accordance with legislation on protected species:
 - Eggs may be removed so birds abandon the site.
 - Nest destruction should occur at intervals of at least two weeks.

- Management of Protected Species

- Swallows (Hirundinidae) are legally protected; nest destruction or bird removal is prohibited.
- If necessary, artificial nests may be installed in non-sensitive areas before spring (migration return period – March to April). Installation must strictly follow the manufacturer's guidelines.

