Technical Guide No. 2

Management of bovine parasites and wildlife coprophagia

LIFE+ Chiro Med Program 2010–2014

Intergrated conservation and management
of two bat species
The Greater Horseshoe Bat and Geoffroy's Bat
in the Mediterranean region of France

LIFE+ CHIRO MED

is a Life*+ "Nature and Biodiversity*"
Dedicated specially to two species of bats :

The Greater Horseshoe Bat and Geoffroy's Bat

Photo cover : V. Hénoux.

Contents

Bats, mammals that testify to the state of the biodiversity

From their position in the food chain, bats are good indicators of the ecological status of natural habitats.They are in effect directly impacted by the alteration of the ecosystems* in which they live. They are the flag bearing species* whose conservation involves many issues where man has a role to play.
In the course of the XXth century the numbers of the 34 species identified on French metropolitan territory has vastly declined. Their rapid regression has aroused, for the last few decades, an interest from naturalists and scientists who seek to better understand the problems which weigh against them. The improvement in knowledge of these problems, as well as that of the biology of the ecology of bats, allowed them to propose methods to protect them. These methods are put in place on a case by case basis or within the framework of larger programs (The Regional Action Plan in favour of bats) and for the last few years has given positive and encouraging results and reinforces the continuation of scientific and technical research.

A strong concentration of the species in the south of France

Metropolitan France houses 34 of the 41 bat species present in Europe, of which a third are threatened or near threatened[1] because of the change in their environment. The Mediterranean, the Rhone Valley and the Alps have the highest diversity.For example, the regions of Provence-Alpes-Côte d'Azur and Languedoc-Roussillon Coast are home to 30 species.But these regions also have the highest proportion of threatened species at national level. The responsibility for these regions in terms of conservation is paramount.

Services rendered* to man, and unsuspectedly, from bats

- **An economic and health issue :** All species of European bats are insectivores. They eat tons of insects during the night including some pests of cultures2. They therefore play a natural and free regulating role in the control of insect populations and thus contribute to reducing the purchase and use of pesticides. A study Science has been able to estimate the economy of the U.S. agriculture could reach 53 billion dollars[3].

- **A natural fertilizer :** Bat guano is a powerful natural fertilizer because of its high nutrient content.

- **Recent scientific research into future medical issues :** The special morphology and physiology of bats are studied in many fields of medical research into new technologies for the exploration of body by imaging, and are providing solutions on viral outbreaks and cancers[4].

[1] Selon l'Union Internationale pour la Conservation de la Nature (UICN) et le Muséum national d'Histoire naturelle (MNHN). 2009.
[2] Jay M., Boreau de Roncé C., Ricard J.-M., Garcin A., Mandrin J.-F., Lavigne C., Bouvier J.-C., Tupinier Y. & S. Puechmaille. 2012. Biodiversité fonctionnelle en verger de pommier : Les chauves-souris consomment-elles des ravageurs ? *Infos CTIFL*, 286 : 28-34.
[3] Boyles J. G., Cryan P. M., McCracken G. F. & T. H. Kunz. 2011. Economic importance of bats in agriculture, *Science*, vol. 332 (6025) : 41-42.
[4] Zhang G. *et al.* 2013. Comparative analysis of bats genomes provides insight into the evolution of flight and immunity. *Science*, 339 (6118) : 456-460.

All bats are protected by law by means of :

- **International law,** by the Bonn Convention and the Berne Convention signed in 1979 and ratified by France in 1990. And by the agreement "EUROBATS*", created in 1991 and ratified by 31 countries, which commits signatory states to implement a concerted protection of the populations of bats from the European continent.

- **European Union law,** by Annex IV of the "Fauna-Flora-Habitat" Directive* (92/43/EEC) of 21 May 1992 dictates that all species of bat need of strict protection. Twelve species in France are listed in Annex II of the Directive, which lists species of community interest whose conservation requires the designation of Special Zones of Conservation (SZCs). Thus, bat populations, including their roosts and their habitats* were included in the designation of sites of the European Natura 2000 network.

- **French national law,** by Article L.411-1 of the Environmental Code and the Ministerial Decree of 23 April 2007 (Official Journal of 10/05/2007) which establishes the list of terrestrial mammals protected throughout the country and the terms of their protection. The new law now protects all species of bats currently present in metropolitan area by name, as well as the protection of breeding sites and resting places of the species, necessary for the proper performance of their life cycles.

A very specific life cycle

THE GREATER HORSESHOE BAT

The Greater Horseshoe Bat (*Rhinolophus ferrumequinum*) is the largest Horseshoe Bat in Europe. The main feature of this species is the morphology of his nose, decorated with a leaf-shaped horseshoe essential for echolocation.

Longevity : 15 to 30 years
Size : about 7 cm
Wingspan : 33 to 40 cm
Weight : 15 to 34 g
Coat : brown, more or less a type of red (dorsal) and grey-white to yellowish-white (ventral
Ultrasound : between 79 and 84 kHz (Frequency Constant

Reproduction : Females reach sexual maturity at 2-3 years. Their mating, in autumn, is accompanied by a winter sperm storage in females. Ovulation occurs when the sunny days return. Then their gestation lasts between 6 and 8 weeks, with a maximum of 10 weeks when spring is particularly unfavorable. From mid-June to late July, they give birth to one young per year which learns to fly at between 19 and 30 days, and is autonomous at 45 days.

Movement / Migration : A sedentary species, the Greater Horseshoe Bat rarely moves more than 100 km between breeding roosts* and hibernating roosts* passing through one or more transit roosts* (known maximum distance of travel 320 km).

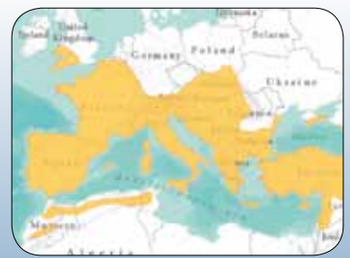

T. Stoecklé

Roosts : In summer, females settle in small groups in warm cavities (21-30°C) and often in buildings(barns, attics, hot cellars, roofs of churches, bunkers...) abandoned, maintained, or new, to give birth and raise their young until emancipation. Males generally pass summer alone.
In winter, the species hibernates from around October-November to April in natural or artificial underground cavities (mines, quarries, caves or cellars) which possess total darkness, a temperature between 5°C and 12°C, humidity at saturation, light ventilation absolute tranquility. These bats hang by the feet (typical of Rhinolophidae).

Hunting Grounds : Essentially wooded (riverine woodland, deciduous forest) and pastureland's surrounded by hedges. Hedgerows are very important for their resources of prey on one hand and also especially as travel corridors on the other (*see* Technical Guide No. 5 "Elements of area conservation management").

Diet : In general, the species feeds on dung beetles (beetles and dung beetles) and nocturnal Lepidoptera, but can also consume Orthoptera (grasshoppers, crickets), Trichoptera, flies, spiders, etc. (*see* Technical Guide No. 5 "Elements of area conservation management").

Distribution : Populations have much reduced in the north-west of Europe during the last century, sometimes completely disappeared (Belgium, Netherlands, Malta) **The epicenter of the European** distribution is in the **Mediterranean basin**.



Source carte : IUCN (International Union for Conservation of Nature) 2008.
Rhinolophus ferrumequinum. In : IUCN 2013. IUCN Red List of Threatened Species.

GEOFFROY'S BAT

Geoffroy's Bat (*Myotis emarginatus*) is medium in size with a distinct indentation, almost at right angles to the outer edge of his brown ear. His coat has a dense woolly appearance, red on the back, lighter on the belly (not much contrast).

Longevity : up to 18 years
Size : about 4-5 cm
Ears of medium size : from 1.4 to 1.7 cm
Wingspan : 22 to 24.5 cm
Poids : 6 to 15 g
Tragus* : sharp and does not reach the top of the notch in the ear
Ultrasons : begins at 140 kHz and ends to 38 kHz (Frequency Modulated Steep)

Reproduction : Mating take place in autumn. The females store sperm until spring. Ovulation occurs when the warm days return, and birth of one single young per year takes place between mid-June and late July, after 50 - 60 days of gestation. The youngster is capab e of flying at the age of 4 weeks.

Movement / Migration : A largely sedentary species. The distances between summer roosts and winter roosts is generally less than 40 km (maximum known movement : 105 km).

Roosts : The breeding roosts are mainly attics or lofts but can be barns, caves, or bunkers as in the Camargue, temperate (23-27°C). Females congregate in swarms of 50 to 600 individuals. Males generally pass summer alone. In winter, the species hibernates in caves, quarries, mines and large caverns which have total darkness, a relative humidity close to saturation, temperature below 12°C and almost no ventilation.


B. Morazé

Hunting Grounds : Mainly forest or wooded areas, deciduous or mixed. However this species also exploits parks and gardens, large isolated trees or small patches of vegetation, stables, pastures, groves, areas above rivers and also, in the Mediterranean, traditional olive groves, coniferous forests and orchards (*see* technical Guide No. 5 "Elements of area conservation management").

Diet : Very specialized, it is composed mainly of spiders, harvestmen and flies, supplemented by Coleoptera, Hemiptera and Neuroptera. In the Camargue there is a local particularity as it is composed mainly of spiders and Odonata, an abundant food resource in the area (*see* Technical Guide No. 5 "Elements of area conservation management").

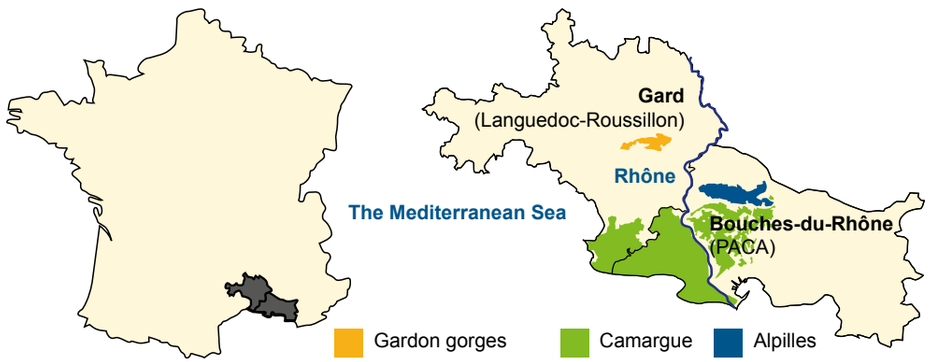
Distribution : The species shows a very heterogeneous distribution over its entire range. In France there are strong disparities depending on the region. **The south of France** has a low population in winter but a **high population in summer**.

Source carte : IUCN (International Union for Conservation of Nature) 2008.
Myotis emarginatus. In : IUCN 2013. IUCN Red List of Threatened Species.

THE EUROPEAN LIFE+ CHIRO MED PROGRAM (2010 – 2014)

The LIFE+ CHIRO MED program (www.lifechiromed.fr) focuses on the conservation and integrated management of two species of bats, the Greater Horseshoe Bat and Geoffroy's Bat, in the French Mediterranean region. The objective of the program is to understand and to preserve each required biological compartment necessary for the annual cycle of local populations of the two targeted species. The strong anthropisation of targeted territories and interactions between the species and humans necessitates an implementation of concerted actions, most importantly close to human activities.

The program focuses on three geographic areas, the **Camargue**, the **Alpilles** and the **Gardon gorges**, and eight sites of community interest, called CIS. In effect in the French Mediterranean region, the main populations of the two species targeted by the program are concentrated in these three territories. In winter, these species hibernate in the cavities of the Gardon gorges and the Alpilles, while in summer they come to feed and reproduce in the Camargue.



The program allows, through 29 actions, to unite technical competence and territorial jurisdictions to overcome the **five major threats to these species :**

- *Threat 1* : the loss and alteration of hibernation and breeding roosts.
- *Threat 2* : the loss and alteration of habitats used as feeding sites (hunting grounds) and travel corridors.
- *Threat 3* : dwindling food resources related to the use of pesticides and modification of agro-pastoral practices.
- *Threat 4* : road deaths.
- *Threat 5* : an ignorance of bats which generates unintended destruction.

To address these threats to the two target species also means protection a large number of other species and their habitats. These are referred to as "umbrella species".

CATTLE IN THE CAMARGUE, WILDLIFE COPROPHAGIA AND BATS

Issues and objectives of LIFE + Chiro Med

Dung insects (Coleoptera* and Diptera*) are one of the main food resources of the Greater Horseshoe Bat. In fact, according to studies carried out in England, Switzerland and Brittany, the Greater Horseshoe Bat feeds mainly on large insects, principally Lepidoptera, Beetles *(Aphodius, Melolontha, Geotrupes)* and Diptera *(Tipulidae)*.

In the Camargue, the diet analysis conducted as part of the LIFE+ CHIRO MED program (Action A8) confirmed the previous analysis, even if the proportion of beetles seemed to be less than elsewhere.

The conservation of populations of Greater Horseshoe Bat involves, in particular, the conservation of their food resources, which includes dung eating insects. However, in the area covered by the project, the main cause of the decline in these species is changing pastoral practices. Indeed, farming has seen the emergence of a new spectrum of anti parasite treatment products which are broad, *powerful and persistent in the treatment of livestock*. Their use seems to have a devastating effect on the coprophagia wildlife on which the Greater Horseshoe Bat thrives. Indeed, these drugs continue to act in dung after being eliminated, thus impacting on insects who exploit it. The worst are those belonging to the family of *Avermectines*, which includes *Ivermectin*, a drug often used on herds in the Camargue.

This disappearance of prey has multiple consequences for the survival of individuals and in particular during pregnancy, the feeding of young, and feeding before hibernation. Together, these impacts can lead to a decrease in or the disappearance of colonies.

This guide, for use by farmers, managers of natural areas, and operators of Natura 2000 sites, is based on the results of several actions (Actions A8 and C5) carried out under the LIFE+ CHIRO MED, program, and also incorporates the results of work by the regional natural park of the Camargue on the management of the internal parasite risk in the Camargue breed of cattle *(Raço di Biou)* and the Spanish breeds *(Toro de Combat and Morucho)*.

The work carried out under the program was designed to meet two main objectives :

- To assess the ability of populations of dung beetles to colonize pastures no longer subjected to treatments based on Ivermectin (Action A8).
- To test, with a number of farmer volunteers, the relevance of a new method in the management of bovine parasitism without using Ivermectin, and to produce a set of specifications proposing a method to facilitate this process (Action C5).

It should be noted that the experimental set up under the LIFE+ CHIRO MED program was deliberately limited to herds of bulls, the most common stock in the Camargue. However, although treatment products and application methods are not same for all types of livestock (equine, sheep, goats), the issue of the impact of *Ivermectin* on the environment is general.

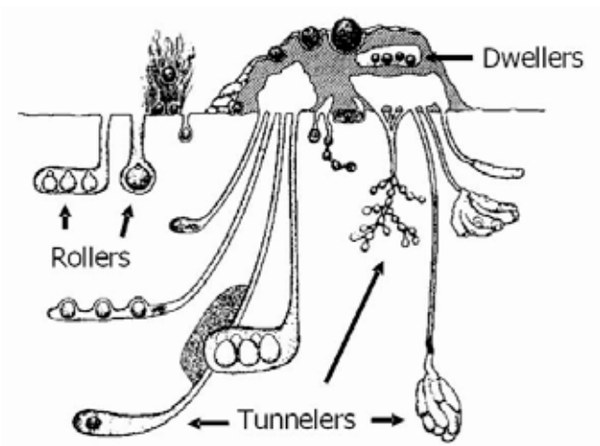
Dung beetles, essential elements of pastoral ecosystems and food resource for bats

Coprophagia are insects that are more commonly called "dung beetles".
They are strictly dependent on faeces for their reproduction, and for feeding both adults and larvae. There are 273 species and subspecies in France.

Onthophagus lemur and Onthophagus taurus Males. © J.-P. Lumaret

We can distinguish three groups among the Coprophagia :

- **The rollers** (the **telecoprides** - rollers) form a ball with faecal matter and they roll it along the surface of the soil, far from the point of dejection. Most of these balls of faeces are buried and serve as food for their larvae.
- **The tunnellers** (the **paracoprides** - *tunnellers*) collect a portion of the dung and bury it directly under or immediately adjacent. They supply their nest pédotrophique* with reserves for their larvae.
- **The dwellers** (**endocoprides** - *dwellers*) who grow in the dung.



Ways of using manure for the reproduction of representatives of the three main groups of dung beetle (rollers, tunnellers, dwellers). (Doube 1990, as amended)

Arrival of the first flies followed by the arrival of dung beetles and dung after work by dung eating insects.
© J.-P. Lumaret

Dung beetles are of great ecological importance because of the role they play in the elimination of dung and the control of parasites that are found in faeces. Indeed, some pastures may play host to 1,000 pieces of dung per day (on average cattle produce a dozen pieces of dung per day) so during a season that means several tons of faeces that must be reincorporated into the ground. However, in the absence of Diptera and Coleoptera cattle dung can take twice the time to decompose, which may represent 3-4 years in a Mediterranean climate, resulting in an increase in refuse (plants growing in the old location of faeces and abandoned by cattle) and therefore a decrease in the effective area of pasture.

The activity of dung beetles thus increases significantly the productivity of ecosystems and ensures production of better quality forage. Dung beetles are also involved in fast and efficient recycling of nutrients and the fertilization and aeration of soil. Indeed, by consuming, burying and aeration of faeces, dung beetles directly stimulate the development of mushrooms, bacteria, and soil Microarthropods* (Collembol*, acarids*...) whose combined actions are essential to the recycling of faecal materials and the recirculation of minerals*.

They also contribute to the reduction of greenhouse gases, in the sense that if a dung is removed by dung beetles, 80% of the nitrogen that it contains is released into the atmosphere.

In addition to their role of shredding, transporting and ventilating the faecal mass*,dung beetles are involved in the vertical dispersion (burial) of the seeds of some plants and are good indicators of biodiversity*.

In the Mediterranean region, their role is essential compared with temperate and humid regions where they share these functions with earthworms, and where rainfall also plays an important role in the elimination of waste. In the Camargue, their role is even more important as cattle breeding is an activity which has increased significantly (almost 20,000 bulls in 2013 against 6,500 in 1977).

Bubas bubalus. © S. Baudouin

CATTLE IN THE CAMARGUE, WILDLIFE COPROPHAGIA AND BATS

Bulls in the Camargue and the principal internal parasites that affect them

Bulls in the Camargue

The traditional breeding of bulls in the Camargue is a tool for the management of natural environments. It is also the vector of a very specific expertise and brings with it a strong local identity.

This farming is mainly concerned with the "Biou" breed (originally from the Rhône delta) and the « Combat » breed or brave ("toros" Iberian origin). These wild farms in the Camargue have management peculiarities which are quite unusual compared to domestic cattle farms (complex and dangerous manipulation).

The manade* is defined in the Camargue as the extensive farming of horses or bulls in semi-liberty. In France there were, in 2013, 148 farms of Camargue bulls and 48 farms of fighting bulls, corresponding to an average of 20,000 and 7,000 animals, two thirds of them situated in the Camargue.

© G. Balmette

The term "bull" is used locally to broadly define all herd animals (males and female, young and old, intact males and castrated males).

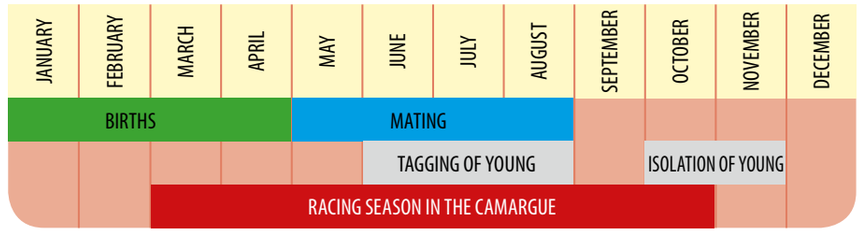
Bulls live outside all year round. Reproduction is completed by natural mating and births take place in the countryside (meaning in the pasture) usually without veterinary assistance.

Registered at birth, calves should be tagged* before the age of six months. They are generally weaned between 6 and 9 months and isolated in pens often close to habitations for the winter period. Males and females can be separated after weaning and mixed with their peers one year later (heifers and doublens*). Young cattle are marked with a number on their side (corresponding with their registration number) and a design on the thigh (a brand) marking which manade* (herd) they were born in.

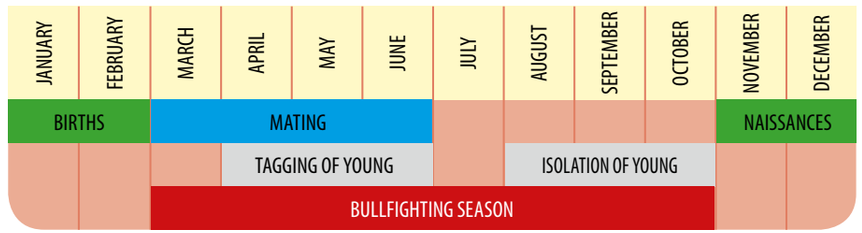
This branding is required to visually identify individuals at a distance.
The bulls of the Camargue are mostly castrated between 1 and 4 years old. Only a few are retained intact for breeding.

The animals live, on average, to 15 years of age for females, 12 years for Camargue males, and 4 years for Combat males. Some breeding stock, famous cocardiers*, or "Toros" given clemency, can die their own death in the countryside at the age of up to about 22 years. Animals are grass-fed throughout the year, with a feed supplement in winter. Only some groups of "toros" prepared for shows (and occasionally some cocardiers*) are fed extra cereal or granules.

Example schedule followed by a herd of Camargue bulls



Example schedule followed by a herd of « Combat » bulls



In the management of these herds, farmers endeavour to maintain the wilderness of character of these animals in order to appreciate their nobility and bravery. Their main use is distinct between these breeds :

- Camargue bulls involved in Camargue races (races or « à la cocarde ») and also street races.
- The "toros" participate in bullfight or « corrida »* following the Iberian culture.

Animals that are not selected for reproduction or for performances are used for meat production, this being classified Appellation d'Origine Protégée (AOP). © Reev'

It is a secondary production to enter into the logical process of slaughter related to the selection of animals for bullfights.

© Y. Estève

Herds of these two breeds are managed in a similar manner over the year of operation, depending on their age, gender or intended use (« cocardiers* », « védélières* » bullfighting,...).

The Camargue, a wetland with a warm climate, is conducive to the development of external and internal bovine parasites. The risk of infestation is present almost throughout the year, unlike other regions of France. Herds grazing in the marshes are very exposed to the parasites of the area (Common liver fluke and Paramphistome).

Cattle are deliberately very little manipulated by some farmers, committed to the conservation of their wild and defensive character. The few manipulations which are made are traditionally done on horseback. Anti parasite treatments are usually completed when the cattle are rounded up into retaining pens for their annual prophylaxis.

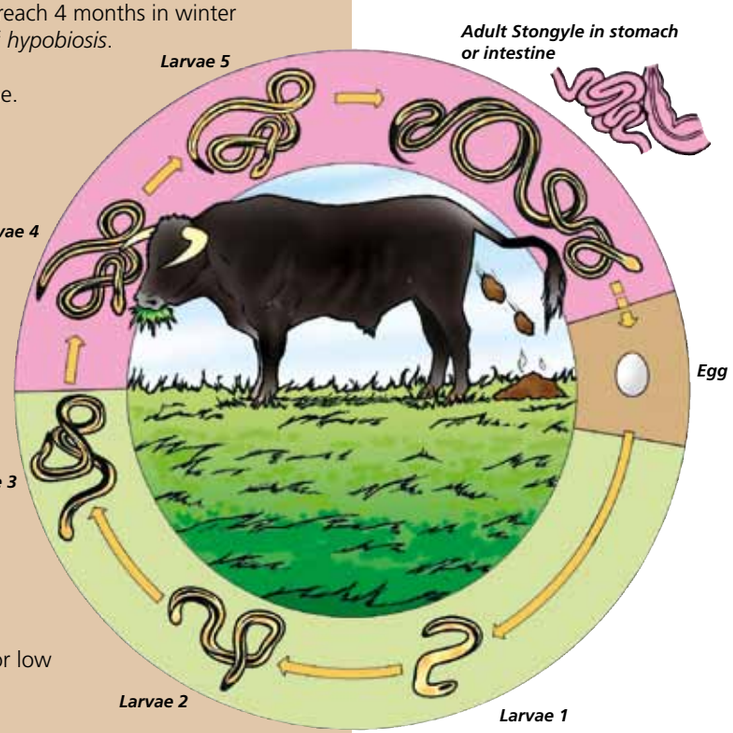
Amis des Marais du Vigueirat

The parasites in the Camargue - *Description of parasites*

Digestive Strongyles

Digestive **strongyles** are roundworms that, present in large quantities, cause problems with the gastrointestinal tract*, mostly in young animals.
There are several genres including *Haemonchus* and *Ostertagia* in the stomach*, *Cooperia* and *Nematodirus* in the small intestine, *Oesophagotomum* in the large intestine. The most pathogenic is the *Ostertagia* in the stomach.
These gastrointestinal strongyles (SGI) are ingested with the wet grass eaten by cattle containing larvae of parasites stage L3. These larvae are conveyed to the stomach or small intestine where they reach the adult stage after about a month (transition to stage L4, and then immature adult form called stage 5, before becoming an adult). Immature adults can become encysted* in tissues and spend some time in *hypobiosis** in this form. Adult female worms then produce eggs that are released into the dung. The eggs hatch into larvae that move from stage L1 to L2, then L3 ; L3 larvae when ingested, are in the stage of infestation.
The adult parasite can survive 4-6 months in the animal.
Immunity in cattle develops within 2 to 3 months.

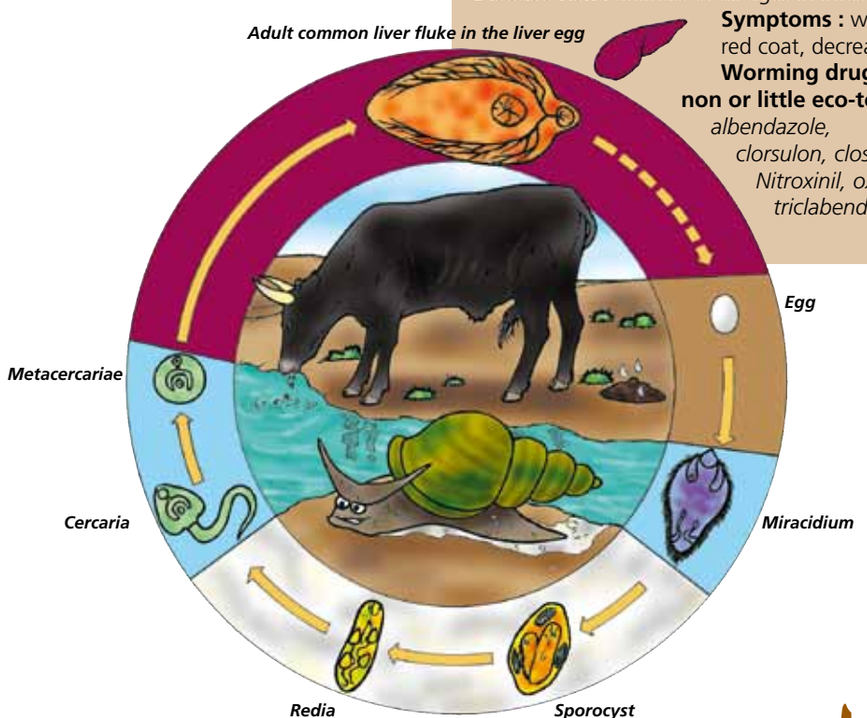
Prepatent period* :
3-4 weeks in summer, can reach 4 months in winter due to the phenomenon of *hypobiosis*.
Form of infestation :
grass infected with L3 larvae.
Risk of disease :
young animals.
Symptoms :
diarrhoea, lack of appetite, emaciation.
Worming drugs* non or little eco-toxic :
albendazole, febantel, fenbendazole, levamisole, morantel, moxidectin, nétobimin, oxfendazole, oxibendazole, piperazine, thiophanate.
Worming drugs ecotoxic :
avermectin (abamectin, doramectin Eprinomectin, ivermectin).
Natural worming* substances :
phyto and aromatherapy for low infestation



Common Liver Fluke

Common Liver Fluke *(Fasciola hepatica)* is a flatworm (fluke) of the bile ducts of the liver which feeds on blood (blood-sucking parasite). Because of its large size, in fragile liver tissue this is a major pathogenic parasite.
The cycle of the Common Liver Fluke requires development in an intermediate host : the pond snail (small wetland snail). A miracidium* ingested by the pond snail multiplies into redia to produce hundreds of cercariae* which are released into the lung mucus of the mollusc, and then into the water.
The stage of infestation is represented by encysted *metacercariae** which are ingested by cattle from the water they drink or the dew on the grass that they graze on. A wet area is necessary for the development of the Common Liver Fluke. The metacercariae* ingested releases immature Flukes into the gut that will take 7-8 weeks to migrate to the bile ducts of the liver.
3 months after ingestion, the adult Flukes appear in the liver, 2-3cm long and 8-13 mm wide. They have a flattened body and can survive several months and in the bile ducts.
Common Liver Fluke reproduction is completed by mating between two individuals. Eggs produced are flushed out by bile and released into the dung.

Prepatent period* : 3 months.
Form of infestation : drinking water or wet grass with *metacercariae**.
Disease risk : animals of all ages in infested areas.
Symptoms : weight loss, red coat, decreased fertility.
Worming drugs* non or little eco-toxic :
albendazole, clorsulon, closantel, Nitroxinil, oxyclozanide, triclabendazole.

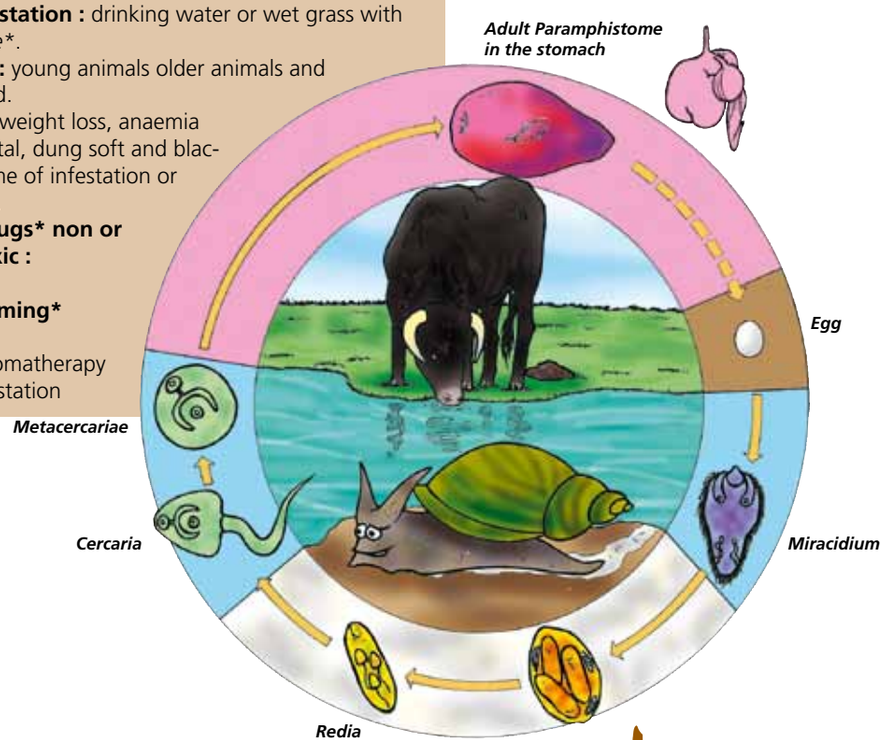


The Paramphistome

The Paramphistome *(Paramphistomum daubneyi)* is a flatworm (fluke) which, in large amounts, cause extensive damage to animals during the larval migration from the intestine to the belly in young animals.

Some researchers believe that the immature parasite use the lymphatic vessels, cross the diaphragm to the lungs and migrate to the stomach. Immature larvae are hematophagous (they feed on blood). The adult parasites attach themselves to the wall of the stomach and are *chymivores* (they feed on its contents).
The adult stage can be up to 5-7 years in the stomach of the animal. The accumulation phase of this parasite, because of its durability, is superior to that of other parasites who have a shorter adult life.
The eggs of *Paramphistome* can survive for 2 years in an exterior environment.
The infectious stage is the metacercariae* which are encysted on a blade of grass and which can survive for six months.
The appearance of *Paramphistome* on Camargue farms could be correlated with the extensive use of medication that targeted the Common Liver Fluke, but which is ineffective against *Paramphistome*. The common intermediate host, the pond snail, is also responsible for the development of this new parasite. The *Paramphistome* is difficult to treat, because it can only be done orally.

Prepatent period* : 3 months.
Form of infestation : drinking water or wet grass with *metacercariae**.
Disease risk : young animals older animals and / or weakened.
Symptoms : weight loss, anaemia sometimes fatal, dung soft and blackish at the time of infestation or *re infestation*.
Worming drugs* non or little eco-toxic :
oxyclozanide.
Natural worming* substances :
phyto and aromatherapy for weak infestation

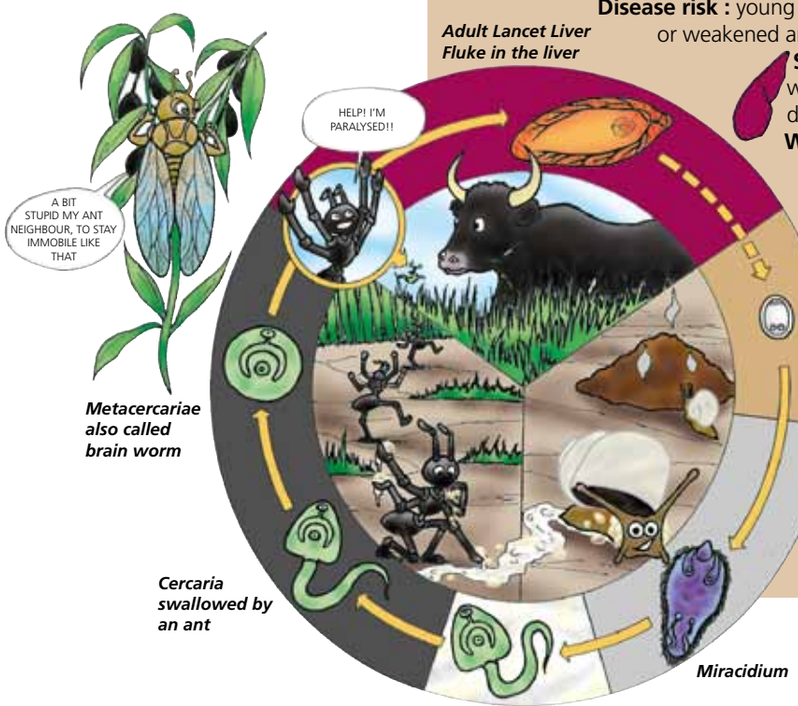


Lancer Liver Fluke

The **Lancet Liver Fluke** liver *(Dicrocoelium dentriticum)* is a flat worm (fluke) of the liver bile ducts which must pass through two intermediate hosts to develop, a land snail *(Cionella lubrica)* and an ant *(Formica fusca)*.
Do not confuse : The Lancet Liver Fluke is not a form of immature Common Liver Fluke, but a different parasite.

The Lancet Liver Fluke in adult stage feeds exclusively on bile. The eggs are evacuated in dung, ingested by the snail, will hatch and give a miracidium which gets into the hepatopancreas of its host. It becomes a sporocyst* 2 months after ingestion. The Cercariae* will then be rejected in balls of mucus after 3 to 5 months, which must be ingested by an ant to continue their cycle, in which they become encysted in the form of *metacercariae**. A cyst localized in a ganglion nerve causes a change in behaviour by the ant which places itself on top of the blades of grass where it is likely to be swallowed by cattle. The immature released in the intestine of cattle will migrate to the liver, there they will reach adult stage and produce eggs. These eggs can withstand 2-5 years in the exterior environment.

Prepatent period* : 4 to 6 months.
Form of infestation : grass with ants that are infested and paralyzed.
Disease risk : young animals and older and / or weakened animals in infested area.
Symptoms : weight loss, red coat, decreased fertility.
Worming drugs* non or little eco-toxic : *albendazole* (4 times the dose of treatment for strongyles) *nétobimin* (3 times the dose of treatment of strongyles) *thiophanate*.
Natural worming* substances : phyto and aromatherapy for weak infestation



Other parasites can affect cattle of the Camargue such as :

Ascaris

Ascaris *(Toxocara vitulorum)* are roundworms (15 to 20 cm long) that live in the intestine hail and cause *ascariasis** or toxocariasis*. They may be very harmful to calves when they exist in excessive quantities.
The calf may be infested in the uterus or via milk from its mother. In adult cattle, the parasite becomes encysted.
It is reactivated at the time of gestation and infects calves when they are deficient in food.
The presence of Ascaris in adults is characterized by a state of immunity exhaustion.

Prepatent period* : 4 weeks.
Form of infestation : uterus, milk or colostrum infested with larvae.
Risk of disease : young calves still with the mother.
Symptoms : digestive disorders can cause occlusions and respiratory problems (cough, rapid breathing).
Worming drugs* non or little eco-toxic : albendazole, closantel, moxidectine, fenbendazole, flubendazole, levamisole, netobimin, oxfendazole, piperazine.
Worming drugs* eco-toxic : avermectins (abamectine, doramectine, eprinomectine, ivermectine).

Tapeworm

The Tapeworm *(Moniezia benedeni)* is a long flat worm, a parasite of the small intestine.
Attached by its four suckers, tapeworm grows by feeding on what the cattle ingest. It forms a long ribbon ranging from 3 to 5m. After 2 to 4 months of implantation in the intestine, it is able to excrete eggs in releasing some of his last coils (rich in eggs) into the dung. The cycle requires an intermediate host, a small oribatid* grassland mite. The presence of tapeworm in adults is characterized by a state of immunity exhaustion

Prepatent period* : 2-4 months.
Form of infestation : grass infested with *oribatid*.
Risk of disease : weakened calves and adults.
Symptoms : abdominal pain, transit and appetite disorders.
Worming drugs* non or little eco-toxic : *albendazole, febantel, fenbendazole, nétobimin, oxfendazole, oxyclosanide, praziquantel.*

Coccidia

Coccidia *(Eimeria zuernii, E. bovis, E. auburnensis)* are protozoa* (single-celled) that cause coccidiosis* with black diarrhoea, by interfering with digestive mucus.
They are always present in small quantities in adults, but when in massive quantities in young animal is in poor health : viral infection, poor diet, etc. The *infective form oocyst**, can withstand several months in the exterior. Calves eating a poor diet and in poor hygiene conditions may have severe forms.

Prepatent period* : 5-9 days.
Form of infestation : skin of the teats covered in oocysts*.
Risk of disease : calves with their mother.
Symptoms : bloody diarrhoea, dehydration, weight loss, nerve problems.
Worming drugs non eco-toxic or eco-toxicity unknown : *amprolium, diaveridine, sulfadimethoxine, sulphadimidine toltrazuril.*
Natural substances : phyto and aromatherapy very effective.

Respiratory Strongyles

Respiratory strongyles *(Dictyocaulus viviparus)* cause verminous bronchitis (strongylosis bronchial or *dictyocaulose**). These are large roundworms (5-10 cm) which in adult stage are located in the bronchi of the animal. The female lays eggs that hatch immediately into L1 larvae which are swallowed by the animal and pass into the digestive tract to be excreted in the droppings. In the external medium, they grow without an intermediate host, in stage L2 and L3 they are in the form of infestation.

Prepatent period* : 3 weeks.
Form of infestation : In grass with L3 larvae.
Risk of disease : weak calves and young adults.
Symptoms : Cough, shortness of breath, runny nose, loss of appetite, weight loss.
Worming drugs* non or little eco-toxic : *albendazole, febantel, fenbendazole, levamisole, moxidectin, nétobimin, oxfendazole, oxibendazole, thiophanate.*
Worming drugs* eco-toxic : avermectins *(abamectin, doramectin, eprinomectin, ivermectin).*

Trichinella

Trichinella *(Trichuris globulosa)* are roundworms that lodge in the large intestine and cecum* of ruminants. They have little or no pathogens.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CATTLE IN THE CAMARGUE, WILDLIFE COPROPHAGIA AND BATS

Parasites : friends or foes ?

The bulls of the Camargue bulls are the target of many particularly virulent external parasites during the summer.

These parasites may be insects such as flies, horseflies and mosquitoes called locally "*mangeance*" ; mites (ticks, mange...), lice or fung (ringworm...). Some of these parasites, in addition to their direct effect on the animal, can also be the vector of disease from their bite (leukemia, *bluetongue*...). This guide deals specifically with internal parasites. All ruminants harbour internal parasites, present in small quantities, they are tokens of good immunity. In excessive amounts, in the case of *polyparasitism*, or when the animal is in a state of poor health, parasitism may cause the death of the animal.


Anti-parasite treatments in the holding pen for bulls in the Camargue.
© P. Daniel

Parasites, friends or enemies :
it's all about balance :

– Ruminants and parasites coexist and form a balance with a close friend - enemy relationship. It is an excess of parasites that causes an imbalance and becomes dangerous.

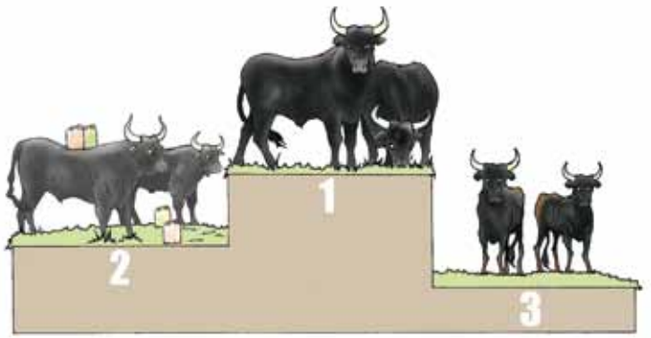
– The natural defences' against parasites are immunity, acquired immunity and genetic resistance.

– Immunity in cattle is its ability, natural or acquired, to defend itself, the immune system, by the recognition of organisms and foreign substances in the body triggers defensive measures against parasites (white blood cell production and synthesis of antibodies). This works when the animal is in the presence of a small regular amount of parasites.

– The premunition determines the state of resistance of an organization against an infecting agent against all secondary infection by the same agent. It can be zero when excess medication prevents the immune system to develop. An animal that contacts a parasite is then unable to defend itself. It can be submerged by the presence of parasite infestation that is too high. It is balanced when the animal, in the presence of a low parasite infestation and rational medication is able to defend itself through the immune system.

– Some criteria for resistance to infection may be acquired on a genetic basis. Thus, in a herd, the laws of genetics means that an animal may be more vulnerable than another in the face of parasites. External factors such as stress, cold, an injury, may exacerbate this vulnerability.

Protection



In a herd, from 20 to 30% of the animals (the most vulnerable) host 70 to 80% of the parasites. This feature is called "aggregate distribution" by scientists. It is this minority of animals that is responsible for the majority of pasture contamination. This character of resistance has a heritability of 20 to 40%, as the traits of productivity.

The source of parasitic re-infestation is linked to the cattle themselves, through eggs laid by parasites which they host then reject in their droppings. These eggs develop outside to the stage of infestation for the animal. It is also linked to the presence of host intermediaries in the grazing pasture, necessary for the development cycle of some parasites. These intermediate hosts are ubiquitous in Camargue : snails and ants for Lancet Liver Fluke, snails in the *gatilles** for *Paramphistome* and Common Liver Fluke.

For the flukes, it can also be due to the proximity of infested wild animals (who are reservoirs of parasites such as raccoons, rabbits, foxes, wild boars, etc.) or domestic animals who share the same pasture (sheep, goats, horses, etc.).

Example brush used in some farms of fighting bulls. When the animal is scratching, the drug product present in the small tank touches the animal through the brush. © Manade Fernay

Be careful not to use pyrethroids in this case (ecotoxic drug).

The amount of stock grazing on a pasture plays a role in the pressure of parasite numbers. In a group of animals, the parasite density is proportional to the square of the amount of stock per hectare. In the Camargue, the ranching farming method has an advantage because, even if the parasites are numerous, the fact of having grazing over large areas means a reduction in the pressure.

In short: More grazing space, less pressure from parasites. Ranching allows a reduction of infestation of cattle and therefore a potential decrease in anti parasitical treatments.

Grazing bulls and horses in the Camargue. © Tour du Valat

The sensitivity of the Camargue bulls to the parasite risk

Limiting the population of intermediate hosts is impossible over this territory. The Camargue cattle are highly exposed to the risk of infestation. Moreover, apart from Strongyles, there may be cross-contamination between ovine / bovine and between horses / cattle when pasture is in common, or a potential transmission from wildlife.

Spring and autumn are critical periods in terms of risk, even though contamination can be effected all year round. The summer sun associated with Mistral drought has a destructive effect on larvae from the eggs of parasites in the environment (although the dung, in which they are located has a protective effect). Rare winter frosts, do not play a role in reducing parasitic pressure in the external environment.

The ants, coming up from underground from late February, induce the start of the cycle of the Lancet Liver Fluke. Thus, calves or anoubles* can be in a state of hyperparasites in early summer. Pregnant or lactating cows and young animals appear to be most vulnerable to the risk from parasites.

Sensibility to parasitic risk :

Maximum for calves since premunition does not yet exist, young animals that have not yet absorbed parasites from the pasture. Parasitic larvae once ingested trigger the complex immune processes of the cells and antibodies. Immunity establishes itself in the gastrointestinal tract, the liver, the broncho-pulmonary apparatus or through various tissues during their migration. The acquisition of complete immunity may take several months. Premunition can not properly establish itself if the calf absorbs a small amount of parasites in the early days of grazing (primary infection).

Still important for young cattle under 18 months notably in relation to aggressive parasites like Common Liver Fluke or Paramphistome and to a lesser extent with respect to a massive infestation of the Lancet Liver Fluke. Optimal immunity establishes itself at around 6-8 months for these types of parasites.

Compounded by the decline in immune of ruminants related to changes in the physiological state :
– Before and after calving,
– After excessive weight loss,
– Within 15 days after a change of pasture,
– Following the stress of transport or handling,
– In the presence of chronic disease in the herd (scabies, etc.).

Variable : in relation to the individual resistance of each individual in the herd.

Treat yes, but beware !

Parasite control treatments : toxic drugs ?

Some parasite control drugs are not without consequences on the environment, especially for wildlife, coprophagia but also for the immune system of cattle.

The environmental toxicity is indicated according to a ranking from the European Directive 99/45/EC or the "Dangerous Preparations Directive" concerning the classification, packaging and labelling of chemical preparations and in particular specialties characterized by the hazard symbol "N" associated with different phases of risk.

 N Environmental hazard Substances or preparations which present or may present immediate or delayed danger for one or more components of the environment.	R50	Very toxic to aquatic organisms
	R51	Toxic to aquatic organisms
	R52	Harmful to aquatic organisms
	R53	May cause adverse effects in the long term in the aquatic environment
	R54	Toxic to flora
	R55	Toxic to fauna
	R56	Toxic to soil organisms
	R57	Toxic to bees
	R58	May cause adverse effects in the long term to the environment
	R59	Dangerous for the ozone layer

Table of classification of risks to the environment (source : Donger 2013)

Generally, the longer it takes to eliminate a toxic drug, the greater the environmental risk, not to mention the risk of parasites developing forms of resistance.

Impacts on coprophagia*

Some active drugs contained in parasite control treatments for livestock can adversely affect dung beetles and diptera coprophagia.
The effect of treatments on the environment varies according to :

- The period of treatment (insects active or not),
- The practices of farmers (number of animals treated)
- The drug used and its rate of degradation,
- The mode of administration,
- The frequency and dose,
- The target species.

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The drugs used (or their metabolites*) which are *released* through urinary or faecal tracts into the environment often retain their initial properties, particularly insecticides. The active ingredients of the anti-parasitic treatments can thus be classified according to their toxicity to the coprophagia.

We can distinguish two groups of parasite control substances according to their persistence, that is to say in terms of the time it takes for the insecticide to act after application :

– Drugs that are rapidly eliminated through faeces (half-life of elimination less than 2-3 days).

– Systemic antiparasitic drugs, in particular macrolides *endectocides* (that is to say, drugs that are effective against ectoparasites and endoparasites), but also synthesis of *pyrethroids*, of which residues can be still detectable infaeces for a month or more after administration.

– Fast transit parasite control.

Among the drugs that are rapidly eliminated through faeces, some are relatively harmless to wildlife coprophagia (*Benzimidazoles*, and *Imidazothiazoles Salicylanilides*). On the other hand, other drugs which are rapidly eliminated via faeces are harmful to wildlife coprophagia (Phenothiazines, *Coumaphos*, *Ruélène*, Piperazine, *Dichlorvos*). Their residues may be found in livestock manure after treatment, sometimes preventing the survival of larval Diptera for almost 15 days, with a concentration sufficient to kill adults of certain species of dung beetles. *Pyrethroids* may (depending modes of administration) be quickly eliminated but more often they are stored in the body of the animal, with a gradual release in the faeces during several weeks. We can also attach them to the following category.

– Systemic antiparasitic drugs

Endectocides are drugs that are effective against ectoparasites and endoparasites. Among them are macrocyclic lactones that are systemic. They are stored in the body, and then gradually *release* during several weeks or months depending on the mode of administration.
Macrocyclic lactones all have neighbouring *ecotoxicological* properties. Highly lipophilic* they are very poorly biodegradable, with high affinity for the soil and organic matter. They include *Milbemycin* (*Moxidectin, Milbemycin* oxime and *Nemadectin*) and the *Avermectines* (*Ivermectin*, *Abamectin, Doramectin*, and *Eprinomectin* among the most common). The Avermectines are suspected to have particular affect on non-target wildlife coprophagia, unlike the *Milbemycins*, like *Moxidectin* which are degraded in the liver of animals where they lose most of their insecticidal properties before ending up in droppings. The results of studies comparing *Moxidectin* to *Avermectines* show that this drug is 64 times less toxic to flies and dung beetle larvae than *Abamectin*.

In France, because of its frequency of use, *Ivermectin* is proving to be the parasite treatment the most hazardous to non-target wildlife coprophagia.

Ivermectin Case

Placed on the market in 1981, this antiparasitic drug revolutionized worming treatments by its effectiveness.
In 1996, it was a the base of the first veterinary medicine sold worldwide. It is present in particularly powerful anti-parasitic drugs with a large spectrum. The worldwide success of *Ivermectin* can be explained by its effectiveness at low concentrations and over a long period, from its large spectrum and from the anticipation of its marketing compared to its competitors.
The *Ivermectin* residues found in manure silently contaminate the environment and affect non-target wildlife such as dung beetles.
The presence of Ivermectin in dung can change the attractiveness of the droppings for dung beetles, and also alter their diet and reproduction. Suddenly, biological cycles and services performed by dung beetles in the pasture systems decreases, affecting the productivity of agro ecosystems. *Ivermectin* impacts coprophagia in different ways depending on the species affected. Those whose larvae develop within the same faeces are the most affected. The presence of Ivermectin in dung causes a lack of Diptera and dung beetles emerging for several weeks after administration of the product.

In addition to affecting the development of insect larvae, *Ivermectin* also affects the speed of decomposition of manure. During the winter, *Ivermectin* degrades very slowly, with a half-life* of between 90 and 240 days.

Factors aggravating the impact of antiparasitics

– Weakened immune system

Antiparasitics, poorly controlled, can prevent the development of immune defences in animals that they would have acquired if they had been in contact with parasites in a moderate way. In addition, eggs and larvae in faeces expelled *recontaminate* grasslands and encourage the farmer to treat again, starting a vicious circle of worm treatments. Finally, many parasites adapt genetically to worming treatments (development resistance).

– Period of treatment

If antiparasitics are applied at the time the activity and reproduction of insects are at their maximum, it increases the likelihood of damage to non-target wildlife. But it is quite difficult to recommend other treatment periods to farmers, as risk periods often coincide with the phases of reproduction of insects (mainly from April to September). in this case the choice of a less harmful antiparasitic, equivalent therapeutically, is preferred.

– Method of administration

The choice of method of administration is generally decided based on the target parasites (endo- and ectoparasites*), effectiveness and cost of the product, ease of administration, the species of cattle and the system of production (outside or contained). The wild character of the Camargue cattle breed or the Combat cattle is a determinant in the choice of modes of administration.
Intestinal bolus* is the method of administration in which the diffusion of the drug takes longer (several months in general). It is most dangerous for the fauna of invertebrate coprophagia if the drug has proven ecotoxicological properties. This was the case with the *Ivermectin* bolus, but this form of administration was withdrawn from the market.

The administration "pour on*" (transcutaneous application of the product on the back of the animal) results also in a faecal release of the drug used over a long period.
With subcutaneous injection or oral solution, the persistence of *Ivermectin* in the plasma of the animal is relatively short, with a half-life of 8.3 days. Most of the faecal elimination of the drug occurs during the first fortnight after the administration. In the wild, the subcutaneous injections seem to be the most appropriate treatment because they represent a compromise between ease of use, attractive pricing and limiting other impacts.*

ANTI PARASITIC TREATMENTS FOR CATTLE IN THE CAMARGUE

Improve the practice of parasite control treatments

The management of the risk from parasites involves monitoring, to identify and quantify parasites, and possibly to treat when there is an excess to restore a dynamic balance in favour of the ruminants.

To manage the risk from parasites, observe 4 steps

– Know the parasites and their reproductive cycles. In the Camargue, the parasites of most concern are gastrointestinal Strongyles, Lancet Liver Fluke, the *Paramphistome* and the Common Liver Fluke.

– Monitor the health status of animals (note weight loss, diarrhoea, hair which is unkempt and *red*...) and perform faecal matter examinations consistently (and / or possibly serology) according to a clear timetable in relation to young animals of less than 2 years, the latter being the most sensitive.

– Estimate the risk from parasites by correlating stool data with the state of health and treatment history, do not hesitate to seek advice from your veterinarian.

– Choose treatments by selecting medicines corresponding to the results of stool examination and the categories of animal requiring special treatment. It is important not to systematically address all animals blindly, several times year. It is recognized that systematic treatment is the main cause of parasite resistance to drugs.
The use of worming treatments* are useful to remediate parasitism in only 20-30% of the most sensitive animals.

The bovine species is mainly resistant to parasites especially in with respect to gastrointestinal Strongyles. Hardy breeds such as those living in the Camargue are even more so. Thus, faced with digestive Strongyles, animals are able to develop a good immunity. The most susceptible are young cattle whose immunity is not yet properly developed. Adult animals are quite capable, in good conditions of hygiene, to defend themselves by their mere immunity. It is not often necessary to treat them after the age of 2 years.

Young cattle must, itself, develop its own immunity through contact with parasites for at least 4 months. First treatment may therefore be done at the time of tagging (around the age of 9 months). Heifers or *doublens** can be treated individually if diarrhoea is diagnosed.

Bioù. © V. Hénoux

Give bulls the means to defend themselves by themselves : use diagnostic tools and surveillance

Coprology

Coprology is a laboratory test that identifies certain species of parasites present in the organs of animals from eggs present in their dung. The shape, size and colour of these eggs characterize the adult parasites. It also allows to estimate the risk by counting the number of eggs per gram of faeces. Eggs can be identified from gastrointestinal, Lancet Liver Fluke, Common Liver Fluke, *Paramphistome*, *Trichures*, Roundworms, Coccidia and larvae (lungworm). With regard to Tapeworm, its presence or lack of it are identified without quantifying because the quantity of eggs in dung is not proportional to the number of Tapeworms present in the animal (one coil of tapeworm may contain 300,000 eggs and contaminate a few grams of dung).

Warning : parasites may be present in animals without producing eggs (called false negatives). This is related to :

- The presence of latent encysted forms (*hypobiosis**) or immature forms that have not yet become adults.
- The considerable presence of parasites which do not lay eggs after an acute larval parasitosis.

The coprology does not reveal anything despite the presence of parasites.

How take a stool sample in the Camargue ?

To estimate the level of parasites in a group of animals, you must take an equivalent amount (the size of a walnut) from 8 to 10 different, freshly issued stools on the ground (or a final sample the size of a tennis ball). The eggs are resistant to bacterial changes in dung, but larvae from pulmonary Strongyles are fragile and die quickly, which is why you must collect the most recently issued dung.

This sample can be collected, using gloves, in a simple freezer bag, on which you indicate the name of the herd concerned as on the order slip to the laboratory.

This action may be completed by the farmer or a veterinarian. In a group of *védélières** (young cows and mothers), it is important to distinguish dung from the mothers from that of the calves ; two sets of stool samples can be made : cows and calves. Calves are more sensitive, they have not yet developed a fully functioning immune system to naturally defend it against parasites. It is interesting to know their own risk induced by their first exposure to parasites (primary infection) in order to identify possible treatment. Keep samples cool (5-8°C without freezing which will destroy the larvae) before shipment and during transportation.

Transportation of stool samples

Samples should be shipped quickly by the farmer or veterinarian, preferably at the beginning of the week, so that the analysis can be performed by the laboratory upon receipt. They can also be taken directly to the laboratory.

During the hot season, samples should be shipped in a cold reserve. The samples must be sealed and properly identified (name of the herd of animals and name of the farmer). Some Sanitary Defence Groups (SDG) can offer financial support for these analyzes. A specific form must be completed and attached to the samples (check with the local SDG).

Stool analysis

Veterinarians have a rapid test kit giving a first idea of risk. For a more precise and quantified analysis, it is necessary to send samples to the laboratory. It is then essential that the technique used by the laboratory uses potassium *iodomercurate* which is a very dense liquid used for the flotation of heavy eggs (Common Liver Fluke and *Paramphistome*) and larvae (lungworm).

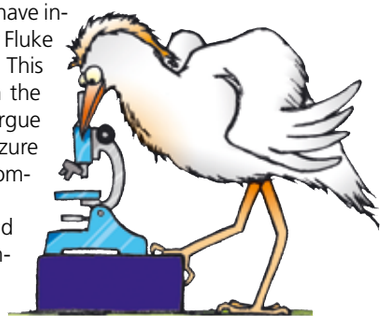
A limited number of laboratories use this technique because it requires protection of personnel facilities that entail a heavy investment.

Interpretation : For each type of parasite identified, the laboratory indicates the number of eggs or larvae, and a degree of risk expressed by one to four crosses (+ low, + + medium, + + + Strong, + + + + Massive).

It is recommended to estimate the risk for different groups of animals on the advice of a veterinarian selected by the farmer (practitioner or SDG), which should take into account the condition of the animals (diseases, thinness, gestation, lactation, grazing density...), the date and the medicine previously used.

Observation of livers at the abattoir (Lancet and Common Liver Fluke)

The observation of livers at the abattoir is an indicator of the health of the herd. Some abattoirs record and keep available to farmers the causes of the seizure of the livers, with the number of the animals concerned. Thus, farmers can have information about the presence of Lancet and/or Common Liver Fluke within the herd from which the slaughtered animal comes. This data has been available from November 2007 in abattoirs in the Pays d' Arles. Data recorded from 2124 livers taken from Camargue herds in 2007 and 2008, indicate that the main cause of seizure was the presence of Lancet Liver Fluke (81%), followed by Common Liver Fluke (18%), and finally abscesses (1%).



The difference can be explained by treatment practices and significant more frequent use of drugs targeted against Common Liver Fluke compared to Lancet Liver Fluke.

Serology (Common Liver Fluke)

Serology, from a blood sample, allows the analysis of serum to detect infestation of Common Liver Fluke due to the presence of antibodies produced by the animal. This analysis can be very useful in young animals in primary infestation, in whom immature parasites in migration cause lesions but are not detectable by coprology since, not being adult, the parasites do not produce eggs.

Thus, a Common Liver Fluke infestation could be detected, in the Camargue, in young calves of only 6 months (medium and massive infestation).

Analysis of the coat (deficiencies and excesses of minerals)

Deficiencies or excesses of minerals can cause immune deficiency and therefore leave an animal susceptible to parasitism. The role of Magnesium is essential, as well as that of Copper, Cobalt, Manganese and Selenium. It is necessary to correct any deficiencies by the use of licking stones or supplements when possible.
However, you must remain cautious about the interpretation of these analyzes is based on a "standard" amount of minerals drawn from domestic cattle breeds which are fed a complement of granules or grains.

Estimate the risk to choose whether or not to treat

After synthesis of stool sample data, the condition of the animals, any stress, and previous anthelmintics* treatments, it is possible to assess the risk according to 4 theoretic levels that are an aid in the decision whether to treat or not.

– Level 1 : low parasitic level, 1 or 2 species present in small quantities (1 +) without the presence of Common Liver Fluke and / or *Paramphistome* in animals more than 2 years old in good health. This parasitic level is characteristic of a stable ruminant / parasites balance. Treatment is mostly useless and even counterproductive with respect to acquired immunity if the drug administered is a 100 % vermicide*. To help with the decision the farmer can perform a coprology test one month later.

– **Level 2 :** average parasitic level, 2-3 species present in low to medium quantity (1 + or 2 ++) without the presence of in animals more than 2 years old in good health. Or 1-3 species present in low to medium quantity (1 + or 2 ++) without the presence of Common Liver Fluke, Lancet Liver Fluke and / or *Paramphistome* in young animals.
This parasitic level characterizes a level less durable than level 1. It is useful in animals over 2 years to implement treatments to stimulate ruminant immunity to enhance resistance. These treatments, based on homeopathy, phytotherapy, and / or aromatherapy however, are difficult to apply on wild adult cattle. For calves in whom parasitism is a significant risk, allopathic treatment can be administered with non-ecotoxic drugs. *Naturopathic* treatment can also support weaned calves for whom it is easier to administer through drinking water or food supplements.

– Level 3 : medium to strong (1 + 2 ++ 3 +++) with presence of 2 to 4 species including Common Liver Fluke, Lancet Liver Fluke or *Paramphistome* in ruminants under 2 years (some of which are thin through disease and stress). Medium to strong (2 ++ 3 +++) in adults with 3 to 4 species including Common Liver Fluke, Lancet Liver Fluke and / or *Paramphistome*. This parasitic level characterizes the start of a collapse in the balance to the detriment of ruminants. It is necessary to treat very quickly using non ecotoxic chemical allopathic drugs, focused on the parasites highlighted. In addition to this treatment, consider a change of pasture, keeping an eye on the loading rate per hectare. Food supplementation and / or correction of mineral deficiencies may be considered. It is useful to perform a coprology test one month later.

– Level 4 : multiple and massive parasitic level (from 2++ to 4 ++++) with the presence of 1 to 4 species including Common Liver Fluke, Lancet Liver Fluke and/ or *Paramphistome* in ruminants under 2 years with severe emaciation of the herd and multiple pathologies ; (from 2 ++ to 4 ++++) with the presence of 2 to 4 species including Common Liver Fluke, Lancet Liver Fluke and / or *Paramphistome* in ruminants of over 2 years. This parasite level characterizes the collapse of the balance in ruminants. It is absolutely necessary to carry out immediate treatment using non ecotoxic chemical allopathic drugs, focused on the parasites highlighted. In addition to this treatment, it is advisable to change the grazing, keeping a low stock level per hectare. If the condition of the animals is very poor, food supplementation should be given, and a correction of mineral deficiencies and vitamins A, D, and E. It is useful to perform a coprology test one month later.

Antiparasitic treatment as a last resort !

If the decision to treat is made, it is recommended that the farmer chooses specific products for the parasites identified and for the stage of the infestation, to take account of the toxicity of the drugs and to vary the active ingredients used from one treatment to the other.

Determine the product best suited to administer, specific and non-ecotoxic

The focus should be on the substance the least toxic to the environment and especially for the coprophagia wildlife, and to choose specific products against the parasite affecting the animal. As a guide, here is a list of some non ecotoxic drugs effective against the parasites most frequently identified in the Camargue.

Prefered drugs		Drugs to avoid or use infrequently		Drugs to be avoided
Netobimin	Cambendazole	Moxidectine	Cypermethrine	Ivermectine
Oxyclozanide	Fenbendazole	Febantel	Deltamethrine	Abamectine
Nitroxinil	Mebendazole	Phenothiazine	Cyhalothrine	Doramectine
Levamisole	Oxfendazole	Coumaphos	Permethrine	Eprinomectine
Albendazole	Imidazothiazoles	Ruelene	Fenvalerate	Dichlorvos
Triclabendazole	Salicylanilides	Piperazine	Diflubenzuron	
Closantel		Alfa-cypermethrine	Clorsulon	
		Flumethrine	Triflumuron	
		Methroprene		

In general, prefer to use drugs that are relatively harmless coprophagia* wildlife, avoid drugs that are rapidly eliminated in faeces but affect coprophagia wildlife* and do not use *endectocides** systemically with a base of *averment*, vermicides* 100% effective which destroys almost all parasites but limits natural immunity.

	Gastrointestinal and pulmonary Strongyles	Lancet Liver Fluke (dicroceliose)	Common Liver Fluke (fasciolose-distomatose)	Gastrointestinal hematophagi Strongyles	Tapeworm	Paramphistome
Netobimin	x	x	x	x	x	
Oxyclozanide			x			x
Nitroxinil			x	x		
Levamisole	x			x		
Albendazole	x	x	x	x	x	
Triclabendazole			x			
Closantel			x	x		
Moxidectine	x			x		
Febantel	x			x	x	

– For drugs specifically active against, prefer to use the injectable or oral drugs such as : *Nitroxinil*, *Triclabendazole* or *Oxyclozanide*.

– Only one drug is effective against *Paramphistome* : it is *Oxyclozanide*.

It is important to remember that the emergence of Paramphistome could be related to excessive use of drugs against Common Liver Fluke which have developed for two reasons : both cycles have the same necessary intermediate host, the pond snail which is highly present in the Camargue, and drugs active against Common Liver Fluke are not active against Paramphistome.

– Two drugs are effective against the Lancet Liver Fluke : they are *Albendazole* and *Netobimin*. The latter is administered orally. This drug is also active against the adult form of the Common Liver Fluke, Strongyles and Tapeworm. However it is not 100% vermicide* at normal dose, which avoids the suppression of natural immunity which is the state of resistance to any secondary infection of an organism already infected.

– Avoid induction of parasite resistance to chemical drugs :
- by alternating families of drugs used by changing them each year,
- by treating only part of the herd and choosing only the weaker animals when they are older than 2 years.

– Unnecessary (usually) to treat cattle of over 2 years against gastrointestinal Strongyles : Except for stress or in particular climates, adult cattle have the capacity to cope with gastrointestinal strongles.

Often, medications combine several drugs for a wide spectrum of activity. The versatile injectable drug most used in the Camargue against Common Liver Fluke is also active against gastrointestinal Strongyles with the presence of *Ivermectin* and *Clorsulon*, drugs that are also effective against Strongyles.

This drug has a dual spectrum, when injected in ruminants of more than 2 years old, it then alters natural resistance in relation to Strongyles in eliminating them.

Choose the method of administration of the drug

Once the effective and non ecotoxic drugs have been selected, it is advisable that the farmer takes into account a number of tips that will enable him to apply a treatment protocol which is the least harmful possible for his livestock and the environment :

• Focus on drugs administered subcutaneously and orally because these formulas are less harmful to the environment, although they require more handling of the livestock. Avoid "pour on" treatments.

• Leave out non strictly necessary treatments (including preventive treatment) and limit the frequency of treatment. This avoids the phenomenon of resistance and limit's the handling of the herd and treatment costs.

• Define periods of treatment of animals based on the life cycle of insects : avoid treatments during the peak of maximum insect activity. It is therefore recommended to treat from October to March.

• Target treatments on the animals most infected and, if possible, depending on the general degree of infestation in the herd, treat only those individuals.

• Follow the recommended doses, not more or less.

Managing the herd : recommendations to prevent re- contamination

Some general advice on managing the herd may allow the farmer to reduce the risk of parasitism.

• Perform extensive grazing : a population of less than 1.4 LU/ ha. Here is a chart used to calculate the number of animals that can be accommodated per hectare.

Bovine	1 bovine from 6 months to 2 years	0.6 LU
	1 bovine > 2 years	1 LU
Equine	1 > 6 months	1 LU

LU = Livestock Unit. This is a unit that allows you to specify the number of cattle on a site (for a hectare we say LU / ha) depending on the type of livestock (bovine, equine, etc.), age of the animals and their nutritional needs.

To reduce the risk of re- contamination by faeces, develop a fold in which to place the herd after treatment, or, in rotation, to keep the animals for several days in old pasture before moving them. This helps to expel waste and parasite eggs in the area of the (closure...) or in the pasture they are leaving.

• Grazing rotations (5-6 weeks)

Rotation in grazing every 5-6 weeks means the non re-infestation of animals with regards to Strongyles that they have issued in their droppings, with a stoppage in the cycle of the parasite. It is necessary to leave the pasture without grazing animals for a few weeks for larvae emitted on the ground to be destroyed by the influence of heat, cold or wind. This rotational system is not always compatible with the practice of ranching, or very extensive farming, as found in the Camargue.

• Avoid grazing near water points after treatment, so that the herds are not re-contaminated by parasites that they reject there. Wherever possible, avoid the drinking of standing water which is more easily contaminated.

• Encourage mixed or alternate grazing, taking care to jointly carry out treatment of all species.

• Winter feeding of calves and young cattle
After weaning, to the extent possible, distribute winter hay to calves in feeders set at a low height rather than on the ground. This prevents re-infestation by larvae of Strongyles (via dung present on the ground among the food).

• Clean water against the risk of parasites
Use a supply where the water (if it does not come from the drinking water network) is pumped into places where it does not stay stagnant, to prevent cattle drinking from the Gatilles* (home to snails) conducive to infestation by Common Liver Fluke and Paramphistome.

• Limiting stress
Stress is an aggravating factor in making animals sensitive to parasites, and should be avoided to the extent possible, combine worming and any stressful procedure (the branding of calves with a hot iron for example).

• Maintain cattle in the best living conditions possible in accordance with local practices concerning breeds : good nutrition, wellbeing, natural landscape, extensiveness of pastures, environment and biodiversity preserved.


Y. Estève

• Whenever possible, do not graze young animals (calves after weaning) on ground previously grazed by adult animals. Keep pastures intended only for young animals. Take into account the health status of adult animals brought into the presence of the young. If calves must be treated at the time of weaning or branding (negative stool results or in a deficient state), it is important that they are all treated at the same time and also, if necessary, the accompanying adults.
During movement to go to races it is unhelpful to treat animals on a piecemeal basis, without targeting those at risk (the need to treat the whole herd).

Veterinary advice
An assessment of the health of the herd can be carried out by a veterinarian. This assessment takes into account the mode of management of the animals, pasture rotations, type of grazing land, the state of health, food, livestock watering and stool results. It can give the farmer a method of rational management against the risk from parasites. Do not hesitate in approaching professionals to optimize animal health practices, taking into account the specifics in conditions for each farm.

Alternative methods

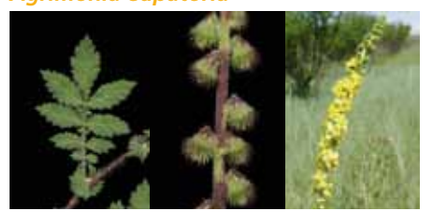
There are many effective alternatives to allopathic treatments.
However they must be accompanied by good husbandry conditions (extensive grazing, quality food, feeders set at the right height, etc.).

Anthelmintic plants
Growing naturally in the Carmargue, they may have, at a certain concentration, a role in worming* cattle. A sufficient quantity of the plant (ie active substances) must be ingested to achieve this. In contrast, over-consumption of some of these plants may cause some toxicity to animals, and may even be fatal.

In the wild, cattle select plants available in their environment to consume, according to their needs and their state of health. Hardy breeds have acquired an ability to find biological solutions, if the ground they graze on gives them the opportunity.
In the natural environment of the Camargue, plants identified as having a potential Anthelmintic* effect are :

– The **Aigrimoiny** (*Agrimonia eupatoria*) grows here and there in areas of Brachypodium of phenicie, and beside paths.

Agrimonia eupatoria


@ PNRC - T. Riquier / V. Noble

ANTI PARASITIC TREATMENTS FOR CATTLE IN THE CAMARGUE

– **Garlic** (*Allium*) : several Allium grow on the *montilles** and the grasslands.

Allium chamaemoly

@ PNRC - B. Huynh-Tan / G. Hemery

Allium polyanthum

@ PNRC - F. Andrieu

Allium vineale

@ PNRC - V. Noble / H. Michaud

– **The Goosefoot**
(*Chenopodium ambrosioides, now called Dysphania ambrosioides*) is here and there in nitrophilous groups.

Foeniculum vulgare

– **Fennel** (*Foeniculum vulgare*) is the real fennel, found around patches of Brachypodium phoenicoides and non salty embankments.

@ PNRC - B. Huynh-Tan

– **Mustard**
(*Sinapis alba* and *Sinapis arvensis* and *Brassica nigra*) grows in patches on the recently brightened up steep banks of the Grand Rhone.

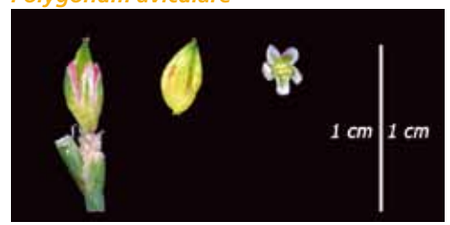
Urtica dioica

– **Nettle** (*Urtica dioica*) is uncommon in the Camargue, where it is found mostly in the vicinity of the mas*. More commonly found in the Camargue is the small annual nettle (*Urtica urens*) and the nettle ball (*Urtica pilulifera*) on some grazing grounds. This plant, with strong stinging power, could be consumed young or well cut and dried.

@ PNRC - B. Huynh-Tan / H. Michaud / V. Noble

Polygonum aviculare

– **The knotweed** (*Polygonum aviculare*) is fairly common in the low salt marshes and the wetlands.



@ PNRC - N. Borel

Ruta angustifolia

– **Ruta** (*Ruta angustifolia*) : is not common in inland dunes (Commanderie, Rieges wood, etc..).

@ PNRC - B. Huynh-Tan

– **Marigold** (*Calendula officinalis*) is common in non salty wasteland.

Salvia verbenaca

– **Sage** (*Salvia verbenaca*) is found in the *montilles** and areas of *Brachypodium* of phenicie.

@ PNRC - H. Michaud

Scutellaria galericulata

– **The Skullcap** (*Scutellaria galericulata*) : Grow here and there in flooded freshwater marshes and along the Grand Rhone.

@ PNRC - J. Molina

Verbena officinalis

– **Vervain** (*Verbena officinalis*) is a nitrophilous plant common in differentenvironments:meadows, *montilles** wasteland, borders, maritime rushes.

@ PNRC - T. Riquier

– Some bark, leaves and fruits, rich in tannins : Bark of pines, oaks, hazel and *chestnut* are rich in tannins. Their leaves and fruits can also play a role. Cases of poisoning of domestic cattle by over consumption of acorns (the tannin content is twice that of the leaves) have been observed. The tannin content varies depending on the growth stage of the plant. Thus, in oak leaves, this concentration increases from April to September. In fruit it decreases during ripening.

Among plants that are foraged, some have been studied for their anthelmintic* effect on sheep and goats, particularly against gastrointestinal Strongyles. They are plants rich in condensed tannins, such as sulla (*Hedysarum coronarium*), birdsfoot and pedunculate trefoils, sainfoin, velvet grass, beans, and also sorghum seeds (mainly old varieties) and millet.

Lotus corniculatus (Birdsfoot Trefoil)

The animals will have more difficultly in assessing the amount of material ingested when it is dry (forage or feed pellets) compared to supplying the growing plants. It is necessary to be particularly vigilant about the presence of certain plant species with an anthelmintic effect in forage or granules to avoid toxic doses. It is recognized that sainfoin hay is three times richer in tannins than grass hay.

Naturopathic management

Naturopathic management of the risk from parasites is based on the principle of letting ruminants live in the best possible way with the parasites in their ecosystem. Warning, it is not a case of replacing chemical drugs with natural medications. This management requires the alignment of several complementary measures to strengthen and stabilize the balance of cohabitation between ruminants / parasites, always in favour of ruminants. To achieve this, it is necessary to implement, on one hand, the creation and ongoing maintenance of natural defences in ruminants (immunity acquired immunity, genetic resistance) ; and, on the other, to decrease the pressure from parasites by using grazing techniques that play on plant and animal biodiversity (rotations of grassland, anthelmintic plants) particularly by enhancing the pastoral ecosystems such as those of dung insects. Monitoring the health of ruminants is paramount. The respect for the routine schedule of coprology becomes essential to build a permanent scoreboard. In case of an imbalance and excess of parasites, the complementary use of medications is required. By prioritising the risk they may be natural (anthelmintic* or immunostimulant of the phytotherapeutic type, *aromatherapy* and / or homeopathy) or chemical and in this case, systematically non ecotoxic.

Phytotherapy is the therapeutic use of medicinal plants and their extracts. This biological stimulation by plants can be used in prevention, support or convalescence, particularly for metabolic actions (functions of the digestive system, drainage of the liver or kidneys).

Aromatherapy is a unique branch of herbal medicine. It is the use of essential oils (EO) extracted from aromatic herbs. The distillation of the aromatic plants selects and concentrates certain substances of essential oil. The non volatile components of these plants (tannins, alkaloids, anthocyanins, flavonoids, etc.) are not found in essential oils.

Homeopathy is a stimulation of the reactivity of the diseased organism with diverse substances in infinitesimal and boosted doses. This provokes an informational and vibratory action on the vital functions of the diseased organism which can help cure the symptoms.
Essential oils generally act faster than plant extracts and in particular are more intense in infections.However, natural medicines are difficult to implement in the Camargue. They require frequent interventions for the cattle (average of two treatments per day), which is not possible for ranch herds. However, an animal in convalescence or calves after weaning, positioned close to the farm buildings, and who are given a compliment of food or drink from a water tank, can receive these treatments. Given the high parasitic pressure in the Camargue it is worth considering these treatments in addition to allopathic medication.

Experimenting with a new management of parasites

One of the actions of the LIFE+ Chiro Med (Action C5) was to test a change in management of parasitism, particularly in the parasite control treatments used by six volunteer cattle farmers. This action was intended to support farmers in adopting practices that are more respectful to the environment and especially to dung beetles, which are known to be the victims of certain veterinary drugs, and are the favoured food source of the Greater Horseshoe Bat. This work verified the relevance of a change in practice on the health of the herd and the constraints placed on farmers (practical and economic constraints). Alongside this, a study of the impact of these changes in practices on communities of dung beetles was established (Action A8 -2).

Study of dung beetles on the dung of bulls treated with *Avermectines* / treated with alternative treatments or untreated

This summary describes the observations of the evolution of the parasite load in cattle subjected to experimentation. Before its implementation, farmers treated their cattle with broad spectrum products containing *Avermectins*, systematic every season and this without knowing the degree of actual infestation of their animals. Under the program, coprology's (identification of parasites by researching the eggs or larvae in their dung) were systematically performed before each treatment. They gave farmers the elements needed to allow them to decide what treatment to administer, by knowing the species of parasites affecting the livestock and the level of infestation.
The coprology's, performed by specialized laboratories allowed the :

- Verification of the presence of parasites in livestock.
- Identification precise of the parasite species when an infestation has been proven : gastrointestinal Strongyles, *Nématodius*, Ascaris, Pinworms, *Strongyloides*, Capillaries, *Whipworms*, respiratory Strongyles (*protostrongles*), Lancet Liver Fluke (*Dicrocoelium*), Common Liver Fluke (*Fasciola*), Cestoda (*Tapeworm*) Coccidia and *Paramphistum*.
- Quantification of the abundance of parasites and thus the assessment of the degree of infestation of cattle.

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They gave farmers accurate information that allowed them to target and administer treatment appropriately and to avoid the systematic administration of broad-spectrum products (with a base of *avermectins*). Some farmers even decided, in view of the stool results not treat their herd. For all herds studied, except that of a farmer who did not follow the protocol, the change in treatment practices has been positive. The health status of livestock is identical or better than that observed before the change in practice.

A socio-economic survey of six farmers

This study was conducted with the participation of six cattle farmers in the Camargue who agreed to experiment with changing pastoral practices.
After four years of implementation of these changes in grazing practices, a survey of these farmers assessed the basic criteria influencing their satisfaction.

From a social point of view :

The six farmers are very satisfied with the change of practice. The additional support by managers of natural areas (AMV, PNRC, SMCG) and by the GDS (Groupement d'intérêt sanitaire - Public Health Group) and by veterinarians has also been an indispensable tool with regard to their acceptance of the process. This support has enabled them to be well advised and guided through the different stages of adopting new pastoral practices that they will be adopting hereafter having been convinced of the benefits to their herd and to their pasture.

From a practical point of view :

If oral administration of new treatments seems to take a bit longer for some, it avoids the risk of stings during injections with dangerous products and recycling waste considered "toxic", also for aquatic fauna. The presence of the veterinarian for the administration of medication is no longer necessary (although the monitoring of the health status of the herd and the prescription of drugs are still his domain) and the use of a long spraygun facilitates administration.
Containing animals of "wild" character requires equipment and therefore any manipulation must be done very carefully because it can be dangerous. In terms of management, operational and solid facilities are essential for safely handling animals during treatment (holding pen, spray gun to inject drugs in the mouth...). However, all herds are already equipped with this kind of equipment and farmers do not have to make alterations "... anyway, the holding pen is mandatory for the ongoing management of livestock" (Manade* I) and the treatments may be performed concurrently with the regulatory bovine prophylaxis without any additional labour.

From an economic point of view :

New products (without Avermectin) are easy to find. They seem to cost a little more expensive, but thanks to coprology's*, treatment is not systematic, which balances spending"... as we only treat 2 times a year instead of 3, it makes no additional cost. I did not need extra labour or incur any other costs in addition" (Manade* F).
The effectiveness of this new practice is indeed based on parasitological analysis. Coprology's* are performed before each treatment, which are used to evaluate the evolution of the composition and the amount of parasites in the cattle concerned. These analyzes make the work much smoother because they directly target the parasites in need of control. Furthermore, if the coprology's* detect no parasites, the farmer no longer treats his animals. This represents a great tool, and even though the cost of a coprology* is low (about 10-12 euros), some Public Health Groups (GDS) will support the cost of coprology's*. There is no change to plan for as regards the processing procedure of treatments except the use of a spray gun to give medicine orally. Manades* operate on the same principle : bring animals into a holding pen that most farms are already equipped with, and treat them one by one.

From the point of view of the health of livestock :

The main motivation of farmers to accept this change in practice was to improve the health of their animals "... my animals were strongly affected by fluke, I was seeking advice and changes to improve their condition" (Manade* F).
It is recognized that systematic treatment is the main cause of parasitic resistance to drugs. With coprology's *, it is possible to target parasites and the most sensitive animals. Systematic treatment of the whole herd is avoided "... it is also faster and less stressful for the animals, when compared to the old practices" (Manade E).
In addition, less treatment means less stress for the livestock, stress is an aggravating factor for susceptibility to parasites.
Farmers are very satisfied with the new practices. Their animals are healthier, they are less frequently brought to the holding pen and they have a beautiful coat.

This change in practice also contributed in improving contact with the animals. Indeed, the trade of cattle farmer is modernizing. It must often combine livestock, agriculture and tourist accommodation. A Manadier* is now more often on his tractor than on horseback, but must always be riding his horse to manage the herd. With new treatments, it is necessary to observe the herd to target the most sensitive animals "... *these changes in practice have not led to major changes in the management of the herd.* The difference is that it is much more about personal perception, to know how to treat wisely with greener products" (Manade C).

From a viewpoint of the environment :
All breeders are unanimous in agreement with this observation : with the new treatments, dung degrades faster and pastures are more beautiful.
Animals graze year round, outside, extensively, in a variety of settings. Maintaining a "clean" environment is essential and it is a priority for farmers "... here we kept the old practice of regular rotations, especially changing of land between summer and winter which ensures that the livestock come back to clean ground" (Manade E).
Most breeders have not really identified the ecological interest of this change in practice "... I 'm not an expert and I do not always look at what you should look at, on the other hand I now keep every year storks with the manade and *herons as guards* around the cattle" (Manade E) but they are happy to contribute to the conservation the environment where they live "... I love to act to protect our environment and I am convinced that this study is good for the medium and long term" (Manade C).

Testimonial : farmers stories

Two farmers were willing to share their experiences on changing the pastoral practices applied to their cattle farming.

Jean-Louis Plo
Manade "Plo"*
© Amis des Marais du Vigueirat

Alain Fougairolles
Manade "de Franquevaux"*
© P. Constantin

Why did you agree to try a change in practice ? What are your motivations ?

Monsieur Plo : "To work for the protection of nature. We practice in the Camargue semi-extensive farming and are therefore contributors to and beneficiaries of the ecological assets of our region".

Monsieur Fougairolles : "At the beginning of the program, I did not necessarily have an opinion, it has changed today".

How have you implemented this change? What aid, counselling or methods have you had to choose your new practices (veterinarian, GDS, AMV, SMCG, PNRC,...) ? What changes have you had in the behaviour of your herd (rate of observation, particularly changes made for care management, product administration, pens and holding areas, other changes...) ?

Monsieur Plo : "The two structures that gave me the most support are the PNRC and AMV. I had many discussions with my vet in parallel. These changes in practices have not led to major changes in the management of the herd. The difference is that it is much more about personal perception, to know how to treat wisely with greener products".

Monsieur Fougairolles : "The SMCG guided me and provided documentation to help with a change in practice. I have not changed dramatically the management of my herd except that I spend more time observing (coats, behaviour, *weight*...). Now, I wait a while after treatment before I change their enclosure. I changed to oral drugs, whereas before I used mainly injections. So, I had to redo my holding pen, but I had to do it anyway because it was in poor condition ; also it serves for the prophylaxis".

How long did it take you to put into practice the change ? Number of years before changing practices ? Time to complete arrangements for the care of the animals ? Time to organize and treat animals ?

Monsieur Plo : "It took us a year to complete the change in practice. No development was necessary and I always work identically. The coprology's* are saving considerable time, especially when they reveal that the herd does not necessarily need to be treated"

Monsieur Fougairolles : "I more time observing the condition and behaviour of my herd, but I handle them a lot less. I am winning in terms of working time and reducing stress for my animals. It's been two and a half years since we changed products. Before I was doing 2 applications per year, minimum, of *Ivermectin* without thinking because it was a habit of our elders. With this change in practice, the animals are better, I target parasites and last year I did not treat at all except a few more fragile animals".

Have you encountered difficulties in implementing this change in practice ?
Have you felt that, or are there, any additional risks for animals ?
Have you felt that, or are there, any additional risks to humans(work force) ?
Does the treatment takes more time ? More labour ?
Is it easy to control non- ecotoxic products ? Do you talk with your veterinarian ? What about ?

Monsieur Plo : "No, I think there is no difference in risk for either animals or ourselves. We take the same time to treat the herd or slightly less. My vet helped me in this process, especially as we did the treatments at the same time as the prophylaxis, which facilitated exchanges between us on the subject. I have no difficulty in ordering products."

Monsieur Fougairolles : "I did not have any difficulty in changing practices. I don't think there is a risk to animals as we are treating them with a suitable product against the parasites observed. Indeed, animals are now in excellent condition, much better than before. Through an oral application rather than an injection, the risks associated with injections are avoided and waste is limited. Now, the presence of the veterinarian is no longer necessary during handling. It is no more dangerous because the pen is well suited. It also saves time since we target the fragile animals and treat them a maximum of twice per year. Animals are less often brought to the holding pen. It isn't hard to find products without *avermectin*. I order them at the pharmacy".
I still talk regularly with my vet on all issues, including the state of the animals and pastures. The change is good."

From an economic point of view, have you seen an economy or rather a surcharge from changing practices ? Cost of the product ? Cost of labour ? Cost of changing equipment for a different mode of administration ?

Monsieur Plo : "The new products, in themselves, are more expensive. But thanks to coprology's* treatment is no longer systematic, thereby balancing expenditures".

Monsieur Fougairolles : "I have clear savings since I no longer have animals in poorer health. The non-ecotoxic product is slightly more expensive, but as we use less quantity, I'm winning. The investment for the holding pen was not excessive, and anyway necessary for the ongoing management of livestock."

Have you identified the ecological interest of this change in practice ?

Monsieur Plo : "Less than you for sure. But I like to do to protect our environment and I am convinced that this study is good for the medium and long term."

Monsieur Fougairolles : "Yes, it is very clear. Dung in my pastures degrades much faster. In two to three months there remains only a third of the dung in an advanced state of degradation. Before, I was obliged to go over it with the tractor each year to break and crumble dung that stayed on the ground. I can not say that it is only the change in product that made my pastures more beautiful, but there is probably a link. I had the explanation from the SMCG on dung on food chain links (food for bats, swallows, *hedgehogs*...). The training I attended, organized at my place, along with other farmers to introduce products and the effect on insects was very rewarding and also showed that to have beautiful ground and a beautiful meadow you must keep these insects."

Shave you identified a change in the health of your animals ?

Monsieur Plo: "No, there is no difference in the health of my animals."

Monsieur Fougairolles: "My animals have been much better off for the last year and a half."

Are you satisfied with this change in practices and do you wish to sustain them ?

Monsieur Plo : "Yes, I am very satisfied with everything. These new methods are no more expensive and no more painful."

Monsieur Fougairolles : "I am very satisfied with the condition of my animals. It is also interesting economically and environmentally. At the moment, I see only good things. I'm ready to continue but I need the support and supervision such as is given by the SMCG."

The development of a set of specifications

A set of specifications was created based on the results of this experiment. Intended for farmers, it may allow those who wish to change practices to be oriented in their approach. It is also useful for managers of natural areas because it can be annexed to pasture agreements. It is available on the website : www.lifechiromed.fr

GLOSSARY

Abomasum : the abomasum is the fourth stomach of a ruminant. It secretes a strong acid and many digestive enzymes. The material that goes into the abomasum of the animal comes from the rumen.

Anouble : cattle one year old.

Anthelmintic : chemical drug or, more rarely, natural substance with specific toxicity for certain parasites, or group of parasites (worms or helminths).

Ascariasis : the ascariaisis is a parasitic disease caused by the infestation of the animal by Ascaris (infection by intestinal worms).

Biodiversity : refers to the diversity of living things. This diversity is expressed and plays a role in all organizational levels of life : diversity of species, diversity in a species, between individuals at any given moment, ecological diversity, the associations of species in a given environment. (source : National Biodiversity Strategy 2011-2020). Variability among living organisms of all origins, terrestrial, marine and other aquatic ecosystems among others, and the complex ecology of which they are part ; including diversity within species, between species and of ecosystems (Source : Convention on Biological Diversity).
Diversity of living organisms, which is assessed by considering the diversity of species, that of genes of each species, as well as the organization and distribution of ecosystems. Maintaining biodiversity is an essential component of sustainable development. (source : Vocabulary of the Environment published in the Official Journal of 12 April 2009).

Bolus : drug capsule, which remains in the rumen, allowing the release of the drug over several months.

Breeding Roosts : from June to September, females gather in birthing colonies and give birth to their single young of the year (from mid- June to late July). Sites occupied by these colonies are characterized by a high temperature, the absence of air flow, the absence of disturbance and abundant food nearby. The most favourable sites are roofs and attics, barns, stables, cracks in trees, warm caves...

Cecum : located after the small intestine, the cecum is the part proximal to the large intestine wherein the fermentation of products of digestion that are not absorbed is carried out, before the formation of faeces.

Cercaria : larva of trematode *distomiens* worms (eg liver fluke), constituting their last stage of development and their form of *infestation.*

Coccidiosis : Coccidiosis is caused by a very small parasite (coccidia) that destroys intestinal cells responsible for the absorption of nutrients, causing diarrhoea and stunting growth.

Coleoptera : insects whose first pair of wings, the elytra, form a shell that covers the membranous wings used for flight.

Cocardier : castrated Camargue bull participating in Camargue races.

Coprophagous : who eats faeces.

Coprophile : living or growing on excrement.

Coprology : identification of parasites by searching for their eggs or larvae in dung.

Dictyocaulose : verminous bronchitis or respiratory strongylosis due to a respiratory strongle called *Dictyocaulus viviparus.*

Diptera : insects characterized by the possession of a single pair of membranous wings.

Doublen : cattle of two years old.

Ecological Niche : the ecological niche is a theoretical concept of ecology. It reflects both the "position" occupied by an organism, population, or more generally a species in an ecosystem and the sum of the requirements for a viable population of this organism.

Ecosystem : functional ecological unit formed by the biotope and biocenosis, in constant interaction. (Source : Glossary of Environment published in the Official Journal on 4/02/2010).

Ectoparasite : an ectoparasite is an external parasite, that is to say, a parasite that lives on the body surface of a living being.

Endectocide : antiparasitic drug active both on internal parasites and the external parasites. Endoparasite : an endoparasite is a parasite living inside its host, feeding on its interior fluid and sometimes eventually kill it.

Encysted : enclosed in the form of a cyst, which is a closed pocket with a membrane separate and developing abnormally in a cavity or body structure. Cysts may contain parasitic organisms "encysted" in active slow reproduction form or inactive form.

EUROBATS : this agreement has the aim of protecting 36 species of bats identified in Europe, through legislation, education and conservation, as well as international cooperation between the signatory countries and other European governments. The signatories to the Eurobats Agreement committed to a common goal : the conservation of the European populations of bats.

Gatille : point of stagnant water.

Gastrointestinal tract : this is a pathway that begins at the lips and ends at anus. This system of organs takes food, digests it to extract energy and nutrients, and expels the excess in faeces.

Habitats Directive Fauna and Flora (Directive 92/43/EEC of 21 May 1992) : a regulation made by the European Union to maintain the biological diversity of the Member States by conservation of natural areas and species of fauna and flora of Community interest. The Natura 2000

network brings together these sites of community interest consisting of Special Conservation Zones defined by the Habitats Directive, and Special Protection Zones as defined by the Birds Directive (Directive 79/409/EEC of 2 April 1979). Annex II the DH list of species whose conservation requires the designation of Special Conservation Zones.

Habitat, Priority Habitat : place where the species and its immediate environment are both abiotic and biotic. (source : Encyclopaedic Dictionary of ecology and science Environment - François Ramade). A natural or semi- natural habitat is an environment that meets the physical and biological conditions necessary for the existence of a species or group of animals or plants. (source Natura 2000).
The habitat of a species is in the midst of the life of a species (breeding area, feeding zone, hunting area, etc..). It may include several natural habitats. (source Natura 2000).
A priority natural habitat within the meaning of Directive 92/43/EEC, is a type of habitat in danger of disappearance, present in the territory of the European Member States to which the Treaty applies, the conservation of which the Community has particular responsibility for given the importance of the natural range within this territory. Types of priority natural habitat are listed in Annex I to the Directive.

Half-life : time taken by a substance (drug, radioactive nucleus, or other) to lose half of its activity, pharmacological, physiological or radioactive.

Hematophagous : refers to an animal that feeds on blood.

Hibernation Roosts : bats hibernate in natural or artificial cavities, such as caves, mines, tunnels, basements, old quarries, cracks, holes in
trees, etc.. These roosts offer them total darkness, absolute tranquillity, a cool stable temperature which protects them from frost, light ventilation, and humidity generally close to saturation to avoid their wings drying out.

Humidity : measurement of humidity of the air. Relative humidity, denoted RH, which is the-percentage of the maximum value of humidity in the air at a specific temperature.

Hypobiosis : state of life slowed down in larval parasites waiting for favourable conditions to resume development.

Manade : defines a farm where horses or bulls in the Camargue are raised in semi-liberty.

Manadier : in the Camargue, farmer of horses or cattle on a manade.

Mas : a mas is a farm in some middle regions of France (Provence, Languedoc,Roussillon). The mas is linked to the rural economy. They are today converted into a holiday homes in these regions.

Metabolite : stable compound derived from the biochemical transformation of a parent drug by metabolism.

Metacercaire : larval form resulting from the forming of a cyst by the cercaria (larva of "Trematoda") corresponding to the last stage of the life cycle of these flukes.

Mineral elements : are nutrients necessary for life. They consist of inorganic salts and trace elements (nitrogen, calcium, iron, magnesium, phosphorus, potassium, iodine, manganese, fluor...).

Miracidium : initial larval stage of certain parasites.

Montille : slight elevation in a flood plain. Name given to small dunes and coarse grassland occupying purely sandy parts of the Camargue.

Novillada : this is a bullfight between young bulls (novillos) with young toreros (matador).

Oocyst : corresponds to the egg wrapped in protozoa's (single-celled organisms).

Oribatid : small mite in leaf litter or soil, with a tough coat, and a varied diet (pollen, mycelium, plant debris, plants).

Ovicidal : that which kills eggs.

Pédotrophique (Nest) : underground nest dug by the dung pile in which adults put faecal material destined as food for larvae.

Prepatent period : period necessary for the larva of a parasite to reach its adult form and produce eggs, after ingestion by cattle.

Protozoan : small single celled organisms, often approaching a millimetre at its largest, may live in colonies. They live in water or moist soil or within an organization (mucus in the lung, intestine, body of some animals...).

Sansouire : salty steppe typical in the Camargue.

Simbèu : bull or cow, usually with a bell, which the farmer uses to lead the flock.

Species : basic taxonomic unit in the classification of the living world. A species consists of all individuals belonging to breeding populations who exchange freely their gene pool but, in contrast, do not breed with individuals constituting of populations of neighbouring taxa belonging to the same population. (source : Encyclopaedic Dictionary of Ecology and Environmental Sciences - François Ramade).
Priority Species : A species of community interest at risk and the preservation of which EU has a particular responsibility for, given the importance of part of its natural range within the European territory of the Member States. Priority species of community interest are listed in Annex II of the Fauna-Flora-Habitat Directive 92/43/EEC.

S**porocyst :** structure that produces and contains forms of asexual reproduction. The sporocysts occur in some animals such as Schistosomes (parasitic worms).

Stercoral (matter) : pertaining to faeces; excrement.

Sub-lethal : related to a toxic amount close to that which would produce death.

Services rendered by ecosystems or eco-systemics : these are the direct or indirect benefits that man derives from nature; they include the provision of services (food, water, timber, fibre, etc.), regulating services (climate, floods, disease, wastes, pollination, etc.), self - maintenance services (soil formation, photosynthesis, nutrient recycling) and cultural services (recreation, aesthetic, spiritual).

Tag/Tagging : involves putting a tag with a registered ID on the ears of young bulls.

The Financial Instrument for the Environment (LIFE+) : the LIFE+ program funds projects that contribute to the development and implementation of environmental policy and law. This particular program facilitates the integration of environmental concerns into other policies and, more generally, contributes to durable development.

Transit Roosts : these are shelters occupied by bats more or less temporarily in spring and autumn. They are quite varied (sheds, barns...), but their conditions are not conducive to reproduction. Their role is still unknown, they often provide a stopping point between winter and summer roosts, and house a large variety of numbers.

Toxocariasis : the toxocariasis is a zoonosis verminous related to the presence of intra-tissue larvae of roundworms "pending", the evolution to adult stage which can only be done in a dog or cat.

Tragus : projecting appendix inside the ear.

Vedeliere : cow breeder.

Vermicide : which kills worms.

Vermifuge : which gets rid of worms.

Zoonosis : infection or infestation naturally transmissible from animals to humans and vice versa.

BIBLIOGRAPHY

Andresen E. & F. Feer. 2005. The role of dung beetles as secondary seed dispersers and their effect on plant regeneration in tropical rainforests. *In* : Forget P.M., Lambert J.E., Hulme P.E., Vander Wall S.B. (Eds.), *Seed Fate : Predation, Dispersal and Seedling Establishment.* CABI International, Wallingford, Oxfordshire, UK, 331–349.

Beck A., Gloor S., Zahner M., Bontadina T., Hotz T., Lutz M. & E. Mühlethaler. 1997. Zur *Ernährungsbiologie* der *Grossen Hufeisennase (Rhinolophus ferrumequinum)* in *einem Alpental* des Schweiz. *In* : Zur Situation der *Hufeisennasen* in Europa. *Arbeitskreis Fledermäuse* Sachsen-Anhalt – IFA *Verlag, Stecklenberg* – Berlin, 15-18.

Bergstrom R. C., Maki L. R. & B. A. Werner. 1976. Small dung beetles as biological control agents : laboratory studies of beetles action on *Trichostrongylid* eggs in sheep and cattle feces. *Proceedings* of the *Helminthological* Society of Washington, 43 (2) : 171-175.

Bioret F., Esteve R. & A. Sturbois. 2009. *Dictionnaire de la Protection de la Nature*. Presses Universitaires de Rennes, 537 p.

Boireau J. 2007. *Étude des terrains de chasse d'une colonie de reproduction de grands rhinolophes Rhinolophus ferrumequinum (Schreber, 1774) en Basse-Bretagne*, FR.

Bornemissza G. F. 1970. Insectary studies on the control of dung breeding flies by the activity of the dung beetle, *Onthophagus gazella* F. (*Coleoptera : Scarabaeidae*). *Journal of the Australian Entomological Society*, 9 : 31-41.

Bruxaux J. 2013. *Effets environnementaux des antiparasitaires endectocides dans le cadre des parcs nationaux et du pastoralisme ; exemple de l'ivermectine*. Thèse Université Claude-Bernard - Lyon I, 130 p.

Caroff C., Duranel A. & S. Y. Roué. 2003. Traitements anti-parasitaires du bétail, insectes coprophages et chauves-souris. L'*Envol des chiros,* 7 : 7-14.

Cambefort & Hanski (eds.). 1991. *Dung Beetle Ecology*. Princeton University Press, New Jersey.

Culot L., Huynem M.-C., Gerard P. & E. H. Heymann. 2009. Short-term post-dispersal fate of seeds defecated by two small primate species (*Saguinus mystax* and *Saguinus fuscicollis*) in the Amazonian forest of Peru. *Journal of Tropical Ecology*, 25 : 229-238.

Davis A. L. V., Scholtz C. H, Dooley P. H., Bham N. & U. Kryger. 2004. *Scarabaeine* dung beetles as indicators of biodiversity, habitat transformation and pest control chemicals in agro-ecosystems. *South African Journal of Science*, 100 : 415-424.

Denholm-Young P. A. 1978. *Studies of decomposing cattle dung and its associated fauna*. Ph.D. Thesis, Oxford University.

Doherty W. M, Stewart N. P, Cohb R. M & P. J. Kieran. 1994. In vitro comparison of the larvicidal activity of moxidectin and abamectin against *Onthophagus gazella* (*Coleoptera, Scarabaeidae*). *Australian Journal of Entomology*, 33 (1) : 71-74.

Donger S. 2013. Impact des pratiques agricoles sur la sélection alimentaire du Grand Rhinolophe – Synthèse bibliographique. CPIE Sèvre et Bocage, 16 p.

Doube B. M. 1990. A functional classification for analysis of the structure of dung beetle assemblages. *Ecological Entomology*, 15 : 371-383.

Dupont P. & J.-P. Lumaret. 1997. Intégration des invertébrés continentaux dans la gestion et la conservation des espaces naturels. Analyse bibliographique et propositions. Ministère de l'environnement/DNP n°67/75 et Réserves naturelles de France, 258 p.

Duvergé L. & G. Jones. 1994. *Greater horseshoe* bats *activity*, *foraging* and habitat use. British *WildLlife*, 6 : 69–77.

Errouissi F., Alvinerie M., Galtier P., Kerboeuf D. & J.-P. Lumaret. 2001. The negative effects of the residues of ivermectin in cattle dung using a sustained-release bolus on *Aphodius constans (Duft.) (Coleoptera : Aphodiidae). Veterinary Research*, 32 : 421-427.

Errouissi F. 2003. Effets des Anthelminthiques sur les Insectes Coprophages. Conséquences Environnementales. Thèse doctorat Biologie des populations et Ecologie, Université Montpellier III, 380 p.

Estrada A. & R. Coates-Estrada. 1991. Howler Monkeys (*Alouatta palliata*), Dung Beetles (*Scarabaeidae*) and Seed Dispersal : Ecological Interactions in the Tropical rain Forest of Los *Tuxtlas*, Mexico. *Journal of Tropical Ecology*, 7 : 459-474.

Feer F. 1999. Effects of Dung Beetles (*Scarabaeidae*) on Seeds Dispersed by Howler Monkeys (*Alouatta seniculus*) in the French *Guianan* Rain Forest. Journal of Tropical Ecology, 15 : 129-142.

Fincher G. T. 1973 - Dung beetles as biological control agents for gastrointestinal parasites of livestock. *Journal of Parasitology*, 59 : 396–399.

Fincher G. T. 1981. The potential value of dung beetles in pasture ecosystems. *Journal of the Georgia Entomological Society*, 16 : 316-333.

Fincher G. T. 1991. Sustained-release bolus for horn fly (*Diptera : Muscidae*) control : effects of *methoprene* and *diflubenzuron* on some *nontarget* species. *Environmental Entomology*, 20 : 77-82.

Floate K. D., Wardhaugh K. G., Boxall A. B. A. & T. N. Sherratt. 2005. Fecal residues of veterinary parasiticides : Nontarget Effects in the Pasture Environment. *Annual Review of Entomology*, 50 : 153-179.

Garde de l'espace littoral. 2002. Les coprophages et la dégradation des excréments. *Revue d'information des Gardes du Littoral*, n°46, fiche 5.21, 5 p. (Disponible sur le site du Conservatoire du Littoral : www.conservatoire-du-littoral.fr).

Gillard P. 1967. *Coprophagous* beetles in pasture ecosystems. *Journal of Australian Institute of Agricultural Science*, 33 : 30-34.

Halffter G., M. E. Favila. 1993. The *Scarabaeinae* (*Insecta : Coleoptera*) an animal group for analyzing, inventorying and monitoring biodiversity in tropical rain forest and modified landscapes. *Biology International*, 27 : 15-21.

Halffter G. & E. G. Mathews. 1966. The natural history of dung beetles of the Subfamily *Scarabaeinae* (*Coleoptera, Scarabaeidae*). *Folia Entomologica Mexicana*, 38 : 29-107.

Herd R., Stinner B. R. & F. F. Purrington. 1993. Dung dispersal and grazing area following treatment of horses with a single dose of Ivermectin. *Veterinary Parasitology*, 48 : 229-240.

Holter P. 1979. Effect of dung beetle (*Aphodius sp.*) and earthworms on the disappearance of cattle dung. *Oikos*, 39 : 213-227.

Holter P., Sommer C. & J. Gronvold. 1993. Attractiveness of dung from ivermectin-treated cattle to Danish and afrotropical scarabaeid dung beetles. *Veterinary Parasitology*, 48 : 159-169.

Jacq E. 2007. *Impacts des produits antiparasitaires sur la faune coprophage des pâtures : bilan et préconisations*. Mémoire bibliographique, Université de Caen. 48 p.

Jones G. 1990. Prey selection by Greater horseshoe bat (*Rhinolophus ferrumequinum*) : optimal foraging by echolocation ? *J. Anim. Ecol.*, 59 : 587-602.

Jones G., Duvergé L. & R. Ransome. 1995. Conservation biology of an endangered species : field studies of Greater horseshoe bat (*Rhinolophus ferrumequinum*). *Symp. Zoll. Soc. Lond.*, 67 : 309-324.

Klein B. C. 1989. Effects of forest fragmentation on dung and carrion beetle communities in Central Amazonia. *Ecology*, 70 : 1715-1725.

Krüger K. & Scholtz C. H. 1997. Lethal and *sublethal* effect of *ivermectin* on the dung-breeding beetles *Euoniticellus intermedius (Reiche)* and *Onitis alexis* Klug (*Coleoptera : Scarabaeidae*). *Agriculture, Ecosystems and Environment*, 61 : 123-131.

Krüger K. & C. H. Scholtz. 1998a. Changes in structure of dung insect communities after *ivermectin* usage in a grassland ecosystem. I. Impact of ivermectin under drought conditions. *Acta Oecologia*, 19 : 425-438.

Krüger K. & C. H. Scholtz. 1998b. Changes in structure of dung insect communities after *ivermectin* usage in a grassland ecosystem. II. Impact of *ivermectin* under high-rainfall conditions. *Acta Oecologia*, 19 : 439-451.

Lançon J. 1978. Les restitutions du bétail au pâturage et leurs effets. *Fourrages*, 75: 55-88 et 76 : 91-122.

Lobo J. M, Hortal J & F. J. Cabrero-Sanudo. 2006. Regional and local influence of grazing activity on the diversity of a semi-arid dung beetle community. *Diversity and Distributions*, 12 : 111-123.

Losey J. E. & M. Vaughan. 2006. The economic value of ecological services provided by insects. *BioScience* 56 : 311-323.

Lugon A. 1996. *Écologie du Grand Rhinolophe, Rhinolophus ferrumequinum (Chiroptera, Rhinolophidae) en Valais (Suisse). Habitat, régime alimentaire et stratégie de chasse*. Mém. Dipl. Univ., Neuchâtel, SZ, 116 p.

Lumaret J.-P. & A. A. Kirk. 1987. Ecology of dung beetle in the French Mediterranean region (*Coleoptera : Scarabaeinae*). *Acta Zoological Mexicana (ns)*, 24 : 1-55.

Lumaret J.-P., Kadiri N. & M. Bertrand. 1992. Changes in resources : Consequences for the dynamics of dung beetle communities. *Journal of Applied Ecology*, 29 (2) : 349-356.

Lumaret J.-P. 1993. Insectes coprophages et médicaments vétérinaires : une menace à prendre au sérieux. *Insectes*, 91 (4) : 2-3.

Lumaret J.-P. & N. Kadiri. 1995. The influence of the first wave of colonizing insects on cattle dung dispersal. *Pedobiologia*, 39 : 506-517.

Lumaret J.-P. & N. Kadiri. 1998. Effets des *endectocides* sur la faune entomologique du pâturage. *Bulletin des G.T.V.*, 3 : 55-62.

Lumaret J.-P. 2000. *Les Coléoptères coprophages : reconnaissance, écologie, gestion. Guide pratique à l'usage des gestionnaires des espaces protégés.* Document technique du stage organisé par l'ATEN et le laboratoire de Zoogéographie de l'Université Paul Valéry, Montpellier III, 128 p.

Lumaret J.-P. & F. Errouissi. 2002. Use of *anthelmintics* in herbivores and evaluation of risks for the non target fauna of pastures. *Veterinary Research*, 33 : 547-562.

Lumaret J.-P., Errouissi F., Galtier & P.-M. Alvinerie, 2005. Pour-on formulation of *eprinomectin* for cattle : fecal elimination profile and effects on the development of the dung-inhabiting *diptera Neomyia cornicina* (L.) (Muscidae). *Environmental Toxicology and Chemistry*, 24 (4) : 797-801.

Lumaret J.-P. 2006a. *Séminaires Parasitologie des herbivores sur milieux secs*. Hénouville (76).

Lumaret J.P. 2006b. T*raitements vermifuges du bétail et incidence écotoxicologique sur les populations de chauves-souris*. Journée interactions entre agriculture et conservation des populations de chauves-souris en Wallonie, BE.

Lumaret J.-P. 2008. *Diversité des communautés de coprophages dans les écosystèmes pâturés : prise en compte de la dimension spatio-temporelle pour une gestion intégrée du parasitisme des troupeaux*. In : Pastoralismes, Biodiversités, Paysages dans les espaces montagnards, Les Rencontres de *Valdeblore* (06), 28-30 octobre 2008. http://www.mercantour.eu/valdeblore2008/images/actes/j1/diaporama_lumaret.pdf

Lumaret J.-P. (dir.). 2010. Traitements vétérinaires conventionnels : des risques pour l'entomofaune et un nécessaire réajustement des pratiques. *Pastoralisme et entomofaune.* Pastum hors série. AFP, CEFE et Cardère éditeur, 128p.

Lumaret J.-P., Errouissi F., Floate K., Römbke J. & K. Wardhaugh. 2012. A Review on the Toxicity and Non-Target Effects of *Macrocyclic* Lactones in Terrestrial and Aquatic Environments. *Current Pharmaceutical Biotechnology*, 13 : 1004-1060.

Malaty S. 2011. *Réponse des communautés de Coléoptères coprophages suite à l'arrêt récent de l'utilisation de l'Ivermectine sur des troupeaux de bovins en Camargue.* Rapport de stage de Master 1 Ingénierie en Ecologie et en Gestion de la Biodiversité, LIFE+ Chiro Med, Université Sciences et Techniques Montpellier II, Les Amis des Marais du Vigueirat, Mas-Thibert, Arles, France, 20 p. + Annexes.

Merritt R. W. & J. R. Anderson. 1977. The effect of different pasture and rangeland ecosystems on the annual dynamics of insects in cattle droppings. *Hilgardia*, 45 (2) : 31-71.

Mittal I. C. 1993. Natural *manuring* and soil conditioning by dung beetles. *Tropical Ecology*, 34 : 150-159.

Nealis V. G. 1977. Habitat association and community analysis of south Texas dung beetles (*Coleoptera : Scarabaeidae*). *Canadian Journal of Zoology*, 55 : 138-147.

Petersen R. G, Lucas H. L. & W. W. Jr. Woodhouse. 1956. The distribution of excreta by freely grazing cattle and its effect on pasture fertility. I. Excretal distribution. *Agronomy Journal*, 48 : 440-449.

Pir J. 1994. *Etho-Ökologische Untersuchung einer Wochenstubenkolonie* des *Großen Hufeisennase* (*Rhinolophus ferrumequinum, Schreber* 1774) in Luxembourg. Non publié, Mém. Thesis, Univ. Giessen, GE : 90 p.

Ransome R. 1996. The management of *feeding* areas for *Greater horseshoe* bats. *English Nature Research Reports* (Peterborough, UK), 174 : 74 p.

Ransome R. 1997. The management of *Greater horseshoe* bat *feeding* areas to *enhance* population *levels*. *English Nature Research Reports* (Peterborough, UK), 241 : 63 p.

Raymond A. 2001. Étude du régime alimentaire de *Rhinolophus ferrumequinum* et *Myotis emarginatus* sur deux sites du Parc Naturel de Camargue. Rapport final d'action LIFE+ Chiro Med, 68 p.

Rock D. W., Delay R. L. & M.J. Gliddon. 2002. Chemistry, pharmacology and safety : *moxidectin*. *In :* Vercruysse, J. & R. Rew. (eds.), *Macrocyclic Lactones in Antiparasitic Therapy*. CAB International, Wallingford, 75-96.

Shoop W. & M. D. Soll. 2002. *Ivermectin abamectin* and *eprinomectin* In: *Vercruysse*, J. & *Rew*, R. (eds.), *Macrocyclic* Lactones in *Antiparasitic Therapy. S.*; CAB International, Wallingford, pp. 1-29.

Sommer C. J., Gronvold P., Holter & P. Nansen. 1993. Effects of ivermectin on two afrotropical dung beetles, *Onthophagus gazella* and *Diastellopalpus quinquedens (Coleoptera: Scarabaeidae)*. *Veterinary Parasitology,* 48 : 171-179.

Strong L., Wall R., Woolford A. & D. Djeddour. 1996. The effect of faecally excreted ivermectin and fenbendazole on the insect colonisation of cattle dung following the oral administration of sustained-release boluses. *Veterinary Parasitology*, 62 (3-4) : 253-266.

Vadon A. & Y. Cornille. 2011. Pour une gestion du risque parasitaire interne chez les bovins en Camargue. *Cahier technique du Parc Naturel Régional de Camargue n°8, 25 p.*

Virlouvet G. 2005. Effets des antiparasitaires sur les insectes coprophages. *Le Point Vétérinaire*, 255 : 42-45.

Vulinec K. 2002. Dung Beetle Communities and Seed Dispersal in Primary Forest and Disturbed Land in Amazonia. *Biotropica*, 34 (2) : 297-309.

Waite R., Macdonald W. B. & W. Holmes. 1951. Studies in grazing management. III. The *behaviour* of dairy cows grazed under the close folding and rotational systems of management. *Journal of Agricultural Science*, 41 : 163-173.

Wardhaugh K. G., Longstaff B. C. & M. J. Lacey. 1998. Effects of residues of *deltamethrin* in cattle *faeces* on the development and survival of three species of dung-breeding insects. *Australian Veterinary Journal*, 76 : 273-280.

Wardhaugh K. G., P. Holter & B. Longstaf. 2001. The development and survival of three species of *coprophagous insect after feeding on faeces* of sheep treated with controlled-release formulations of Ivermectin or albendazole. *Australian Veterinary Journal*, 79 : 125-132.

Waterhouse D. F. 1974. The biological control of dung. *Scientific American*, 230 (4) : 101-109.

Whitehead D. C. 1970. The role of nitrogen in grassland productivity : a review of information from temperate regions. *Commonwealth Agriculture Bureaux (CAB), Bulletin (Commonwealth Bureau of Pastures and Field Crops), Farnham Royal, UK*, 48 : 202 p.

The reports of LIFE+ Chiro Med on different actions are available on the website :
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Between 2010 and 2014, Tanguy Stoecklé directed the film "Une Vie de Grand Rhinolophe / Life of the Greater Horseshoe Bat" under the framework of the LIFE+ Chiro Med program. This film is dedicated to the Greater Horseshoe Bat and tracks a female and her baby throughout their lives. You will see exceptional scenes never filmed before.

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The Technical Guides by LIFE+ Chiro Med

This collection was created by the LIFE+ Chiro Med program
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Each guide addresses a specific theme resulting from the synthesis
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by the European program LIFE+ Chiro Med

The other guides

Technical Guide No. 1

Systems to help with the crossing of roads

Technical Guide No. 3

Developing roosts suitable for breeding

Technical Guide No. 4

Conducting winter surveys in cavities

Technical Guide No. 5

Elements of area conservation management

Technical Guide No. 6

Imaging techniques in the service of conservation