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Option: Parasitology

Theme

Contribution to the study of the gastro-intestinal parasites and ectoparasites infesting rabbits from Djelfa region

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Please accept the expression of my deepest gratitude.

Oumaima

Summary

❖ **Listoffigures**

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❖ List of abbreviations

D.P.S.B: The Department of Budget Programming and Monitoring.
i.e.: That is.
GMQ: Gain Moyen Quotidien (Average Daily Gain).
Q14d: Once every 14 days.
Rpm: Revolutions per minute.
Gx: Growth.
O.c: *Obeliscoides cuniculi.*
O.c.c: *Obeliscoides cuniculi cuniculi.*
O.c.m : *Obeliscoides cuniculi multistriatus.*

Introduction

Introduction

The domestic rabbit is a prized game animal, known and hunted by humans for centuries due to its production of meat, fur and wool.Rabbit farming is increasingly becoming an important agricultural activity in different countries.Both traditional and rational breeding's of rabbits can contribute effectively to the resorption of the protein deficit since the breeding of 3 or 4 rabbits and 1 male is enough to meet the meat needs of a family.In addition, rabbit meat is very rich in protein (21%) and low in fat (10% compared to 25% in beef).Like all animals, rabbits require specific care if we want to ensure their production and reproduction.Therefore, a poor breeding management can lead to reduce in performance**.(Combes et Dalle Zotte, 2005)**

Among the causes leading to reduce in performance are parasitic infections that can appear within farms.Rabbit is known to be a host of different parasitic species of internal as well as external localisation.Among the endoparasites, *Eimeria* spp. which represents a common protozoan mostly found in rabbits and involved in more or less serious intestinal infections, characterized by diarrhea and poor growth of young's. Also, ectoparasites mainly scabies agents are responsible of poor growth and mortality of rabbits within farms **(Abdi etAmokrane, 2015).**

According to **Ait Tahar and Fettal (1990),** rabbit farming has been practiced in Algeria for a very long time. Currently, there are two main farming practices that coexist; the traditional farming, which consists of numerous small farms with 5 to 8 rabbits, less frequently 10 to 20, that are situated in rural areas or on the outskirts of towns (**Saidj et al. 2013)** and the rational breeding, which consists of sizable or medium-sized units focused on marketing of their products **(Farsi, 2016).** Furtherer more, in Algeria the epidemiology of parasitic diseases in rabbits both from traditional and rational farms is poorly understood where few studies have been conducted and published **(Maziz-Bettahar et al., 2018)(Ammam et al., 2022).** For this purpose, the main aim of the present study was to estimate the prevalence of gastro-intestinal parasites and ectoparasites in rabbits from two breeding systems in different localities from Djelfa region.

Bibliographic part

Chapter I

General data on rabbits and major gastro-intestinal and external parasitic diseases in rabbits

Chapter I

I.1.General data on rabbits

I.1.1.Definition of domestic rabbits (*Oryctolagus cuniculus*)

The domestic rabbit (*Oryctolagus cuniculus*) appeared more than 6 million years ago in the Mediterranean region and exists in the wild on all the five continents **(GIDENNE, 2015)**, and its domestication took place in farms close to humans in the middle Ages **(LEBAS et al., 2010)** Understanding the biology of the Rabbit and its dietary needs (favorable conditions) and these pathologies are indeed one of the keys to a profitable production breeding, respectful of the environment and animal welfare, whose main purpose is meat production **(GIDENNE, 2015)** .

I.1.2. Systematic and taxonomy

The rabbit *Oryctolagus cuniculus*, which belongs to the order Lagomorphs, is distinguished from rodents by the presence of a second pair of incisors in the upper jaw **(LEBAS, 2002)**

Class: Mammals

Super order: Slides

Order: Lagomorphs

Family: Leporidae

Subfamily: Leporinae

Genus: Oructolagus

Species: Cuniculus (FOLLET, 2003)

I.1.3. Morphology and anatomy

The overall appearance of a rabbit's body varies by sex. Males are characterized by a large, powerful head, a well-developed chest, relatively thick limbs, and muscle development, whereas females have a combination of general competency, a narrower head, and a more elongated-looking body with a slightly smaller, lighter frame. Only the hindquarters are more developed and the pelvis is wider **(LEBAS et al., 2012)**. The major body parts of the rabbit are shown in (Fig 1).

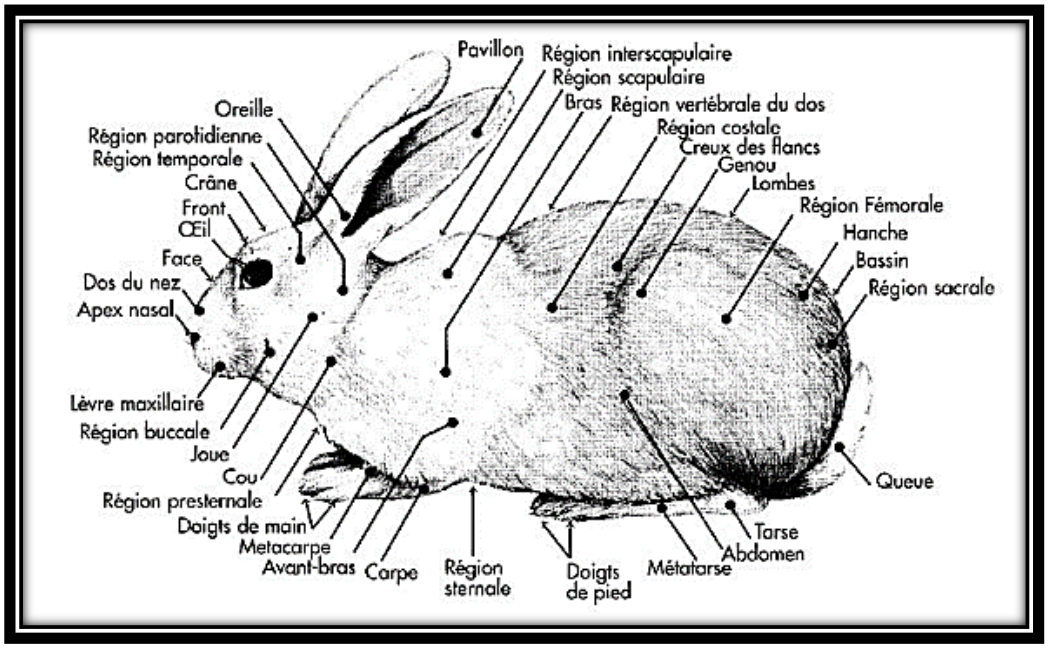

Figure 1: External morphology of the adult domestic rabbit.

(GIDENNE, 2015).

The head, trunk, and tail are the three parts of the rabbit. The neck separates the head from the body.

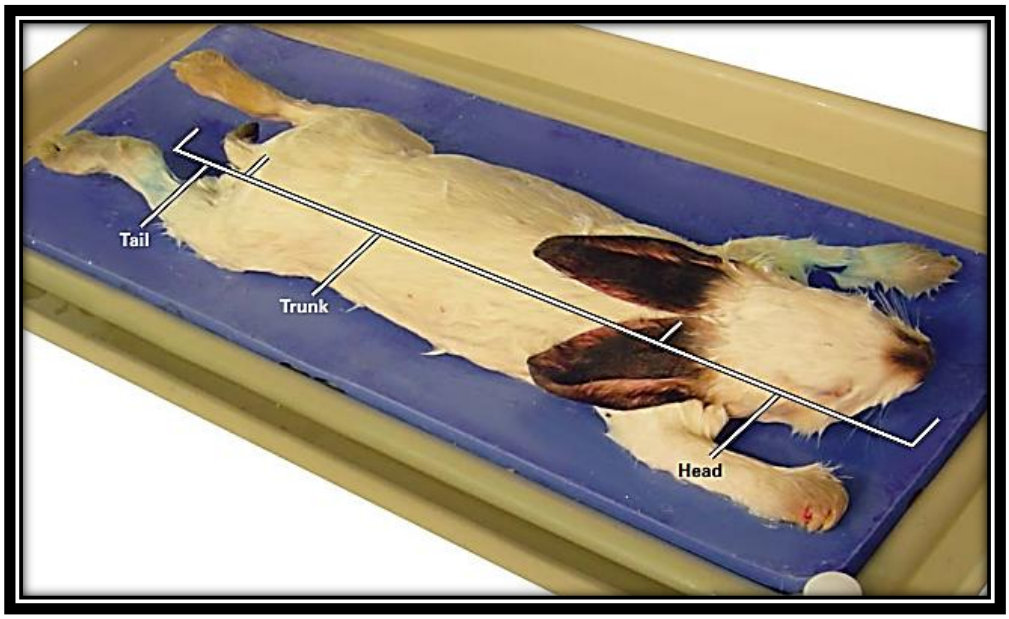

Figure 2: The three sections of the rabbit (Carolina Biological, 2012).

I.1.3.1. Head

The head is large, bulbous at the back but merges into a large, pointed, blunt snout or snout at the front **(Cruise and Brewer, 1994).**

The head has the following structure:

- **Mouth**

Two supple, moveable lips surround the terminal transverse slit-like mouth on the snout. A vertical split that runs up to the nostrils separates the upper lip into right and left halves in the centre. The term "hare lip" refers to a split lip that exposes the upper front incisors **(Cruise and Brewer, 1994).**

- **Outernostrils**

There are two slanted slit-like openings, the nostrils, just above the mouth. The nostrils are surrounded by bare moist skin, the nasal cavity, which leads to the nasal or olfactory cavity **(Cruise and Brewer, 1994).**

- **Vibrissae**

Vibrissae or whiskers, which are thick tactile hairs, extend from the sides of the upper lip. Because they have nerve endings at their roots, the hairs are long, stiff, and sensitive in nature **(Cruise and Brewer, 1994).**

- **Eyes**

There are pair of eyes on both sides of the head, the upper and lower eyelids are movable, and the eyelashes are very thin and short. The small white third eyelid, the nictitating membrane, is also located in the inner front corner of the eye **(Harcourt, 2002).** The nictitating membrane is also mobile and stretches over the cornea and serves to clean the cornea **(Cruise and Brewer, 1994).**

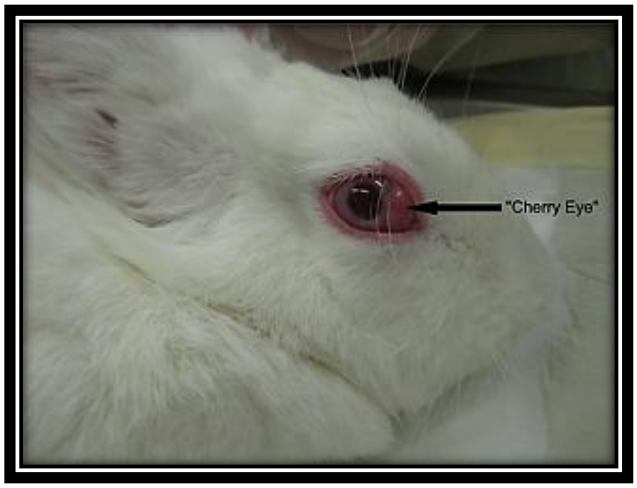

Figure 3: Rabbit with prolapsed gland of the nictitating membrane
(Sohn and Marcelo, 2012)

- External Ears

The posterior lateral side of the head has a pair of large, movable pinnae, also known as external ears **(Cruise and Brewer, 1994).** To receive the sound waves, the long pinnae are movable in all directions. An external auditory meatus is located at the base of each pinna and is sealed off below by the tympanic membrane. When the rabbit is alert and relaxed while running or when it is scared, both pinnae remain upright **(Ninomiya, 2000).**

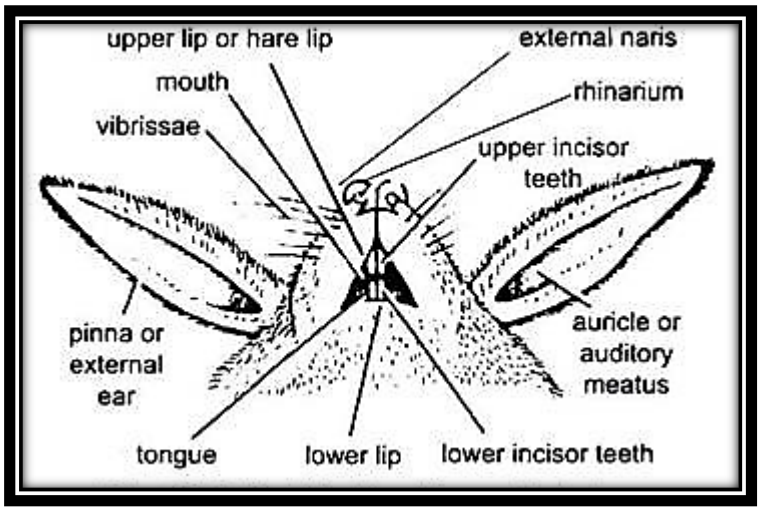

Figure4: Head in ventral view
(Cruise and Brewer; 1994).

I.1.3.2. Neck

The neck, which connects the head and trunk at a slight angle, is an extension of the body. It makes it possible for the head to turn freely. The rabbit has a short, pliable neck. Its quick running and burrowing habits benefit from its short neck **(Cruise and Brewer, 1994).**

I.3.3.Trunk

The large, cylindrical trunk, which is separated into an anterior thorax and a posterior broad, soft-bellied abdomen, comes after the neck. The thorax, also known as the chest, is a bony cage made up of the sternum ventrally and ribs at the sides. The sternum and ribs are absent from the abdomen. Thoracic cavity refers to the area of the thorax that protects delicate body parts like the heart and lungs **(Sohn and Marcelo, 2012).**

- **Teats**

In males and females, the ventral side between the thorax and abdomen is where the 4-5 pairs of fully developed and functional teats or nipples are located. The teats are where the 4 or 5 pairs of mammary glands open **(Ding et al., 2010).**

- **Anus**

The external opening of the digestive tract, known as the anus, is located at the base of the tail at the posterior end of the abdomen. The perineal pouch, a pair of hairless depressions where the ducts of the perineal glands open, is present in both sexes, one on either side of the anus. A strong, distinctive rabbit odor emanates from the perineal gland secretion **(Ding, et al., 2010).**

- **Urethral Aperture**

The male penis tip is where the urogenital opening is located, in front of the anus. The skin surrounds the muscular, cylindrical penis. On either side of the penis, in the male, there are two scrotal sacs where the testicles are housed. Bags of skin with a thin wall make up the scrotal sacs. Underneath the anus, the female has a vulva, a slit-like urogenital aperture, and a rod-shaped clitoris that resembles the male penis at its anterior margin **(Ding et al., 2010).**

I.3.4. Limbs or Appendages

Two pairs of pentadactyl limbs are present on the trunk. Both sets of limbs assist with walking and bear the body's weight. The front limbs are smaller than the back limbs **(Cruise and Brewer; 1994).**

- **Forelimbs**

The front legs are short and firm, designed to absorb shock at the end of a jump. Each forelimb has a distal hand or wrist with a wrist or carpal bone, a palm or metacarpal, and five fingers or fingers with sharp, curved claws. It also has a middle forearm or forearm. Burrows are dug with the front legs. There ishair on it**(Cruise and Brewer, 1994).**

- **Hindlimbs**

In comparison to the forelimbs, the hindlimbs are longer and stronger. Each hind limb consists of a distal foot or pes with four clawed digits, an ankle or tarsus, and a middle shank or crus. First toe, Hallux, is not present. The primary means of locomotion are the hindlimbs. The sole has fur. **(Cruise and Brewer, 1994).**

I.3.5.Tail

At the back of the trunk, there is a short, bushy tail. In wild rabbits, the lower surface of the tail has a white hairy patch that serves as a warning signal to other rabbits when danger is nearby **(Cruise and Brewer, 1994).**

I.1.4. Digestive physiology

Lagomorphs have 28 teeth that develop continuously throughout their life **(LEBAS, 2008).** The rabbit is bipedal, which means it has two pairs of incisors on the upper jaw, with the second pair not functioning or sometimes missing. Premolars present in the latter exist in a constant number while the number of molars varies **(BOUARD, 2003).**

Unlike cows and chickens with gastrointestinal diseases, rabbits are monogastric mammals. These peculiarities are characterized by the specificity and size of their cecum (Fig 2). In rabbits, teeth grow continuously throughout life (≈ 2mm per week**) (LEBAS, 2008).** In the mouth, food is rapidly broken down and mixed with saliva. The food is then rapidly pushed up and down the esophagus and rinsed, usually for no more than 2 minutes. The rabbit cannot regurgitate or vomit: the esophagus is a one-way street **(DJAGO and KPODEKON, 2007).**

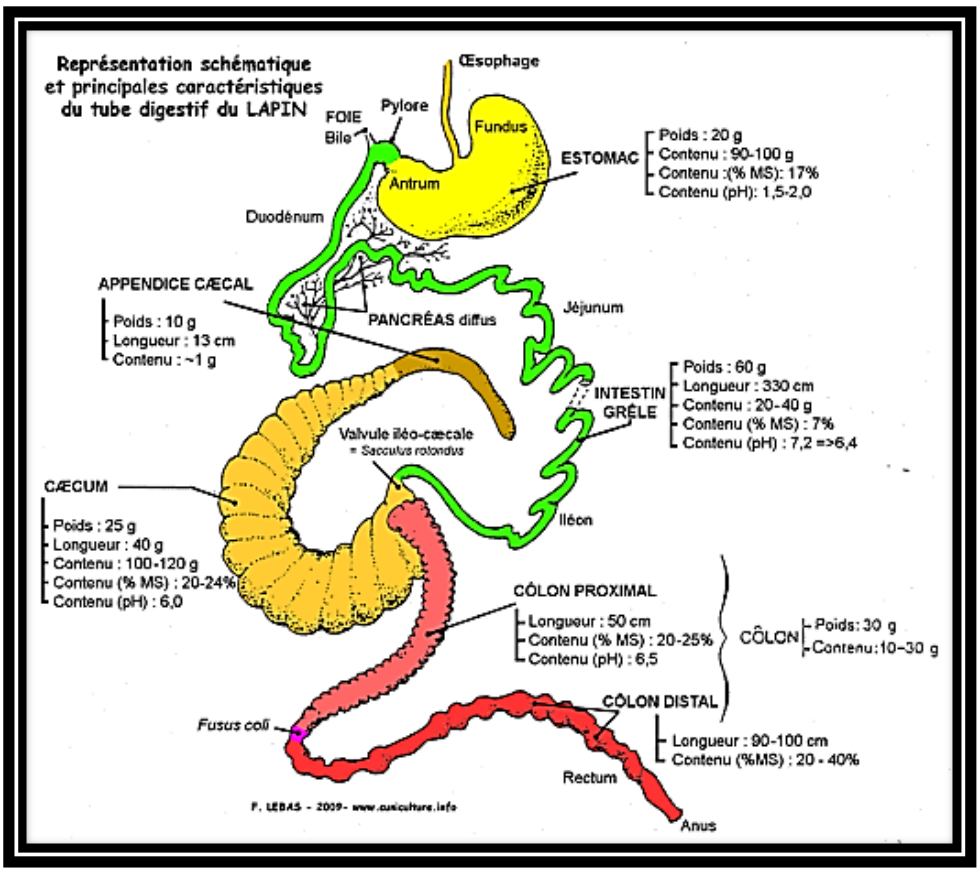

Figure 5: Schematic presentation of the general anatomy and main characteristics of the digestive tract of the rabbit (LEBAS, 2009).

After ingestion, food particles remain briefly in the stomach before passing into the small intestine, where they are attacked by the secretions of the intestine and the pancreas. The liver bile facilitates the action of the enzymes contained in the pancreatic and intestinal secretions. The resorbable elements are then released and absorbed by the intestinal wall. Phase 1 lasts about 4 to 5 hours (3-4 hours in the stomach + about 1/2 hour in the small intestine). The undigested particles and the residues of secretions reach the cecum and are attacked by enzymes that live and multiply there. The assailable elements produced by the bacterial activity are also absorbed there directly.

The cecum's contents are expelled into the colon, the last section of the intestine, after 12 to 18 hours **(DJAGO and KPODEKON, 2007**). Soft excretions, or caecotrophic excretions, appear in clusters of five to ten little balls in the morning and are covered in mucus. The rabbit snatches these up as they emerge from the anus. Other instances, hard

pooping. They are ejected in the litter, spherical, and fiber-rich (Fig.05). The stomach is where the soft excretions, which are abundant in amino acids and vitamins, are found and "processed" along with the remainder of the food. Consequently, a particular particle, which is not very digestive, might be consumed many times (between one and three or four times) before being eliminated in a hard poop **(DJAGO and KPODEKON, 2007).**

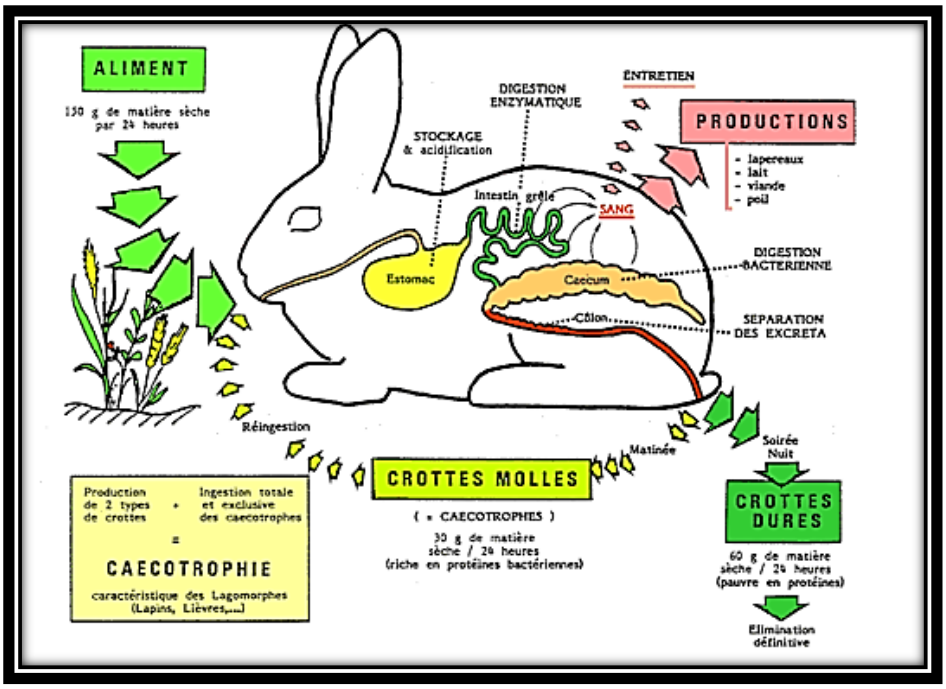

Figure6: General diagram of digestion in rabbits

(LEBAS, 2008).

I.1.5. Feed

The rabbit is a strictly monogastric herbivorous animal. Due to its highly developed digestive system (big cecum) and constantly expanding teeth, it can consume a very high fiber diet that is supplied as fresh grasses and hay **(LINSART, 2016).** A single dry pelleted diet is freely given to caged rabbits **(GIDENNE, 2015).** Depending on the animals' age and physiological condition, the feed's source components and rate of integration change. The diet must satisfy the animal's needs and be tailored to its digestive quirks, and the feed must contain the nutrients essential for the animal's growth and daily activities during all phases of life **(GUEMOUR, 2011).** The rates typically included in rabbit feed are displayed in tab 1 **(MARTIGNON, 2010).**

Table1: Usual incorporation rate of different materials in rabbit feed

Raw material	Rate (%)
Dehydrated Lucerne	25 – 35
Cereals	15 – 25
By-product of cereals	15 – 25
Protein concentrates	15 – 20
Fibrous by-products	05 – 10
Animal or vegetable fat	01 – 03
Molasses	01 – 03
Beet pulp	00 – 10

Between 20 and 30 meals are thought to be consumed each day, more so at night. The typical daily food intake for female rabbits ranges from 150 to 350 g, depending on their physiological stage, and from 100 to 120 g for fattening rabbits.

The mother establishes the feeding schedule for her young rabbits. They start consuming a few grams of the mother's food and a small amount of water around the third week of life **(LEBAS et al., 1996).** Water consumption by rabbits is high, especially for lactating and rapidly expanding rabbits. A breastfeeding female rabbit consumes roughly 0.1 liters daily. A female who is pregnant consumes 1.5 liters daily **(DJAGO et al., 2009).**

I.1.6. Breeds

The breeds can be classified according to the color and structure of the coat, there are 04 breeds of rabbits: heavy breed, medium breed, light breed, small or dwarf **(GIDENNE, 2015).**

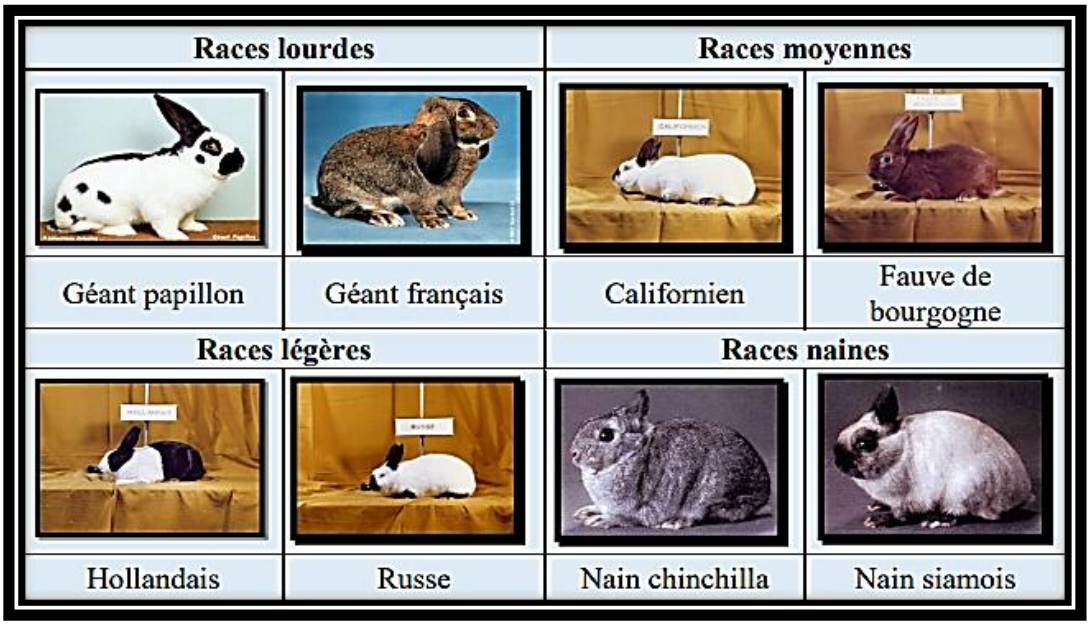

Figure7: Rabbit breeds.
(www.cuniculture.com)

I.1.7. Reproduction

A farm's size is determined by how many rabbits are needed to assure reproduction. We Breeders include both male and female rabbits that are mothers.

The female rabbit can become pregnant at any moment since she experiences an ovulation brought on by mating rather than the cyclic ovulation that occurs in domestic mammals **(LEBAS, 1983).** According to **(SCHIERE, 2004)**, mating must take place when it is the coldest of the day. The female rabbit is transported to the cage for rabbits. After that rabbit needs to be returned to its cage following a successful mating. Typically, the rabbits begin reproducing 10 to 12 days after giving birth (a new gestation period begins at the conclusion of the nursing phase). (A fresh gestation starts at the conclusion of lactation, if the mating is successful) **(DJAGO et al., 2009).**

According to **HOUESSOU (2015),** farrowing typically takes place at night, between 30 and 32 days after mating. The rabbit gathers her resources (straw, shavings, etc.), adds

hair she has plucked off, and constructs a nest out of these items. The young rabbits can be adopted up to three days after giving birth in order to homogenize the litters of eight to nine rabbits by moving extra young to smaller litters and putting young of similar size together with no more than 48 hours between them **(MICHAUT, 2006).**

Weaning, defined by **MICHAUT (2006)** and **HOUESSOU (2015),** is the act of removing a baby from its mother. Typically, this occurs when the baby is 28 to 35 days old. The baby is then placed in a cage to gain weight (complete transition to solid food). There are between 4 and 6 juvenile rabbits each cage when they are being fattened. From weaning till sale, which takes two to three months, the animals' growth is ensured through fattening. Some animals are chosen for reproduction at the end of the fattening period. These animals are picked based on their rate of growth, level of health, and cleanliness.

I.1.8. Breeding systems

A logical rabbit breeding house, according to **(LEBAS, 2009),** is made to shield the rabbits from the elements, including rain, wind, heat, cold, predators, etc. To limit reproduction and make cleaning easier, the rabbits are housed in wire mesh cages or cages with at least a wire mesh floor.

Breeding rabbits and fattening rabbits are segregated in two different cells within the building to guarantee an environment suitable for the needs of the animals: This makes it simpler for the breeder to behave well and follow his bunnies.

In Algeria, rabbit breeding has been practiced for a very long period. Today, we may separate two types of sectors exist: traditional and rational **(COLIN and LEBAS, 1995).**

I.1.8.1. Traditional sector

The traditional sector is made up of numerous small farms with 5–8 rabbits, and less frequently 10–20 **(BERCHICHE, 1992).** These farms are situated in rural or peri-urban settings. Although self-consumption is their primary focus, surpluses are sold on markets. They are reared in colonies or cages housed in historic structures or traditional structures created especially for this function **(COLIN and LEBAS, 1995).** Grass and agricultural by-products make up the majority of the diet. The Around 1980–1990, traditional rabbit farming gave way to rational rabbit farming because of the low productivity of this type of breeding. The intrinsic qualities of the species and its adaptability to various

environments are the reasons for the gradual evolution of farm breeding in Algeria **(DJELLAL et al., 2006).**

I.1.8.2. Rational sector

It didn't appear until the early 1980s as a result of a directive from the government. Although the animals in these farms are typically hybrids imported from France or Belgium, adaptation has not always been easy **(BERCHICHE, 1990).** In wire cages, or at the very least ones with a wire bottom, where the males and females are kept apart, rabbits are bred rationally. To prevent digestive disorders, complete pelleted food for rabbits must contain a minimum of 14% cellulose **(LEBAS, 2009).**

I.1.9. Hygiene and prophylaxis

Due to the susceptibility of rabbits to microbial pathogens, it is important to provide rabbits with a habitat that is protected from external influences such as noise, dust, predators and high temperatures **(LEBAS et al., 1996).** No breeding activity can be carried out without preventive hygiene measures, characterized by strict and rational measures that are often applied:

- The obligation to wear robes and boots reserved for breeding and to wash them regularly;
- Disinfection of hands before any reproductive intervention and after handling sick or dead bodies;
- Soak boots in an effective foot bath with antiseptic solution at the entrance of the building, put on special clothes for visitors (the number must be limited); visitors (their number must be limited);
- Thelitter used in thenestbox must be changedimmediatelywhen it becomesdirty, especiallyduringthefirst 15 days of life;
- Preserving feed in a dry and clean location;
- Ensuring the quality of the water supply and the cleanliness of the sink;
- Regularly cleaning and disinfecting farming equipment and areas. Hair can be eliminated with a flame.
-Once a week, a thorough cleaning of the building is advised, including the walls, air intakes, light points, and cage frames.

Medical prevention enables businesses to uphold a high standard of hygiene. Effective preventive measures for this include disinfectants, insecticides, rodent deterrents, antiseptics for treating wounds, vitamin complexes, antiparasitics, vaccines, and antibiotics **(DJAGO et al., 2009).**

I.2. Major gastro-intestinal and external parasitic diseases in rabbits

I.2. Gastro-Intestinal Parasitic Diseases

I.2.1. Helminthiasis

I.2.1.1. Infection by *Cittotaenia* spp. (Rabbit tapeworm)

Cittotaenia spp. is the culprit. The rabbit's large intestine is home to a 20 cm long flatworm, which is the cause. Eating grass contaminated with mites, which serve as intermediate hosts for the larvae, causes rabbits to become ill. The parasite had every characteristic that one would anticipate from an adult tapeworm from another species. It has several segments and is yellowish. The width of animals varies from 0.5 to 1 cm. Only 3mm of the earliest portion of the neck is wide, and the head is even thinner. Once loaded with fertilized eggs, an animal's terminal parts are shed by rabbits when it reaches adulthood. On vegetation, these eggs fall. A tiny mite belonging to the Oribates family feeds on them, devour them. The following rabbit is then infected by eating oribat andhay alternately**(BOUCHER and NOUAILLE; 2002).**

- **Life cycle**

Once the parasite becomes an adult, the ovigerous segments (the last segments filled with fertilized eggs) are discarded with the rabbit's droppings, another rabbit becomes infested by eating grass containing mites which are the intermediate hosts of the larva **(BOUCHER et al., 2002)**

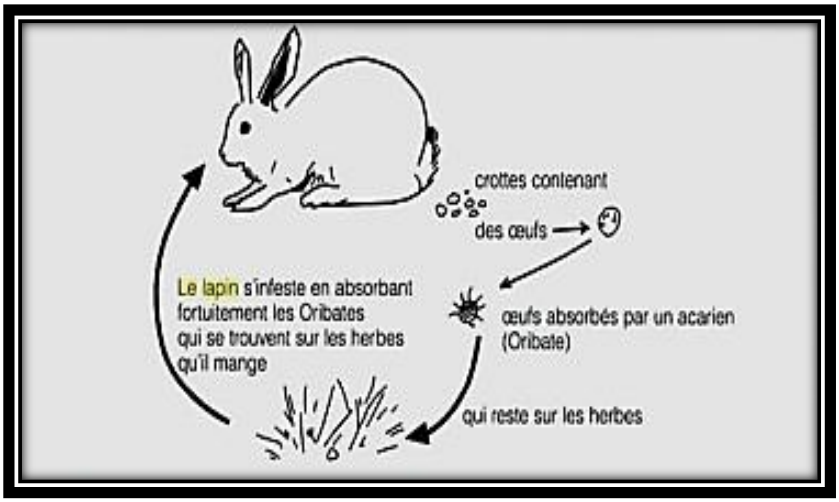

Figure 8: Evolutionary cycle of Taenia (Cittotaenia spp.)

(BOUCHER et al., 2002).

- **Clinical signs**

A small ulcer is frequently seen at the site of the gut where the tapeworm attaches. Usually, the infestation doesn't result in the rabbit's death. The rabbit's growth is hampered, and its energy reserves are depleted. Periodically, meteorization, blockage, or diarrhea may occur.

- **Prevention and treatment**

Using taenicidal drugs like Praziquantel and Niclosamide. Regular cleaning is also done to maintain a clean environment **(BOUCHER and NOUAILLE; 2002**).

I.2.1.2. Infection by *Passalurus ambiguous* (Pinworm)

Rabbits frequently develop Oxyuridosis. It is a condition brought on by pinworms, *Passalurus ambiguous*. They have a small, worm-like appearance. The female measures about one centimeter. The half-man, a male. They are most likely the nematodes that affect rabbits frequently **(BOUCHER and NOUAILLE, 2002).**

Figure 9: Adult worm of P. ambiguussur in rabbit excrement (RAUNIER, 2016).

- **Life cycle**

It has a monoxenous life cycle, and infestation occurs via the oro-faecal route after embryonated eggs are consumed in tainted food or water. However, during the period of caecotrophy. The females either let themselves be dragged into the rectum and lay eggs at the margins of the anus, or they gain the cecum and the large intestine of the hare or rabbit through digestive voice **(BOUCHER et al., 2013).**

- **Clinical signs**

Although *P. ambiguus* is hardly pathogenic, the animals' health status can deteriorate. The females' proclivity to lay eggs close to the anus. Because the females lay their eggs close to the anus, the anal region becomes irritated, which causes frequent itching and scratching. Local superinfections can result from the injuries caused. Massive infestations may result in weight loss, caecal paresis, and mild to moderate diarrhea, and diarrhea **(FAO, 2004).** Up to 5% of a batch can lose fertility due to spoliation and irritation **(BOUCHER, 2004) (BOUCHER et al., 2013).**

- **Treatment and prevention**

Pinworms should be treated with a dewormer such as Soluverm® (or an equivalent) at a rate of one teaspoon per 5 liters of drinking water for five days. For a total of four treatments, this process should be repeated every three weeks.

An efficient preventive treatment would be the administration of, for instance, Piperazine® at a dose of 5ml per 10kg of body weight in a single dose or Soluverm® every three months.

The animal isn't at ease, and it's important to recognize death after an infestation as soon as it happens, which happens very rarely.

For farms or subjects at risk (including apartment rabbits fed green plants, farms where pinworms are frequently found, and rabbits where pinworms are frequently found, green vegetation), routine treatment is necessary.

The use of wire mesh cage bottoms, routine maintenance, and in particular the distribution of a full granule meal are excellent methods for preventing oxyurosis **(LEBAS, 2008).**

I.2.1.3. Infection by *Obeliscoides cuniculi*

Obeliscoides cuniculi, a trichostrongylid nematode parasite, was first discovered in a domesticated rabbit as a result of a natural infection **(GRAYBILL, 1923).**

This parasite is cosmopolite. The term "rabbit stomach worm" is frequently used to describe it. *Obeliscoides cuniculi multistriatus*, which affects snowshoe hares (*Lepus americanus*), and *Obeliscoides cuniculi cuniculi*, which primarily affects eastern cottontail rabbits (*Sylvilagus floridanus*), are the two subspecies that have been identified and recognized to infest Lagomorphs.

Although viable offspring with mixed systemic characteristics were produced in experimental crosses between males of O. c. c. and females of O. c. m, there is no proof that this happens in nature. Although the other subspecies are occasionally discovered, the pet rabbit serves as the organism's type host. The Obeliscoides cuniculi life cycle is straightforward. There is no risk to the public's health from *Obeliscoides sp.* **(Alicata, 1932).**

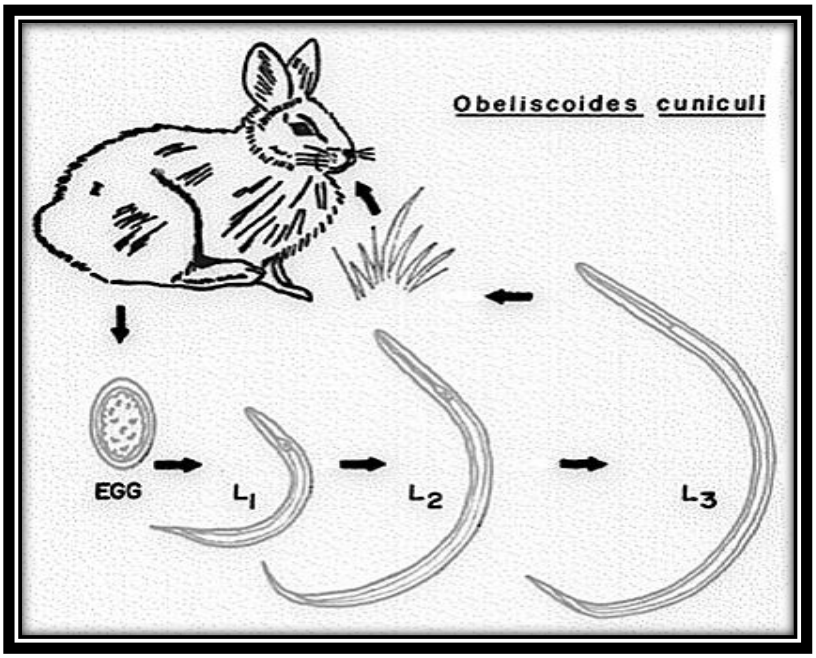

Figure8: Life cycle of Obeliscoides cuniculi.

(www.biosci.ohio-state.edu/~parasite/lifecycles/obeliscoides_lifecycle.html)

The eggs are 83*47 mm, which is a little smaller than those of other subspecies. At the 32-cell stage, they are eliminated in the feces. On day 6, larvae transition from the L1 to L3 instars. Without drying out, larvae can withstand temperatures between -4 and 2 °C. Within an hour of ingestion, L3 larvae shed and started to invade the gastric mucosa. On day 5 following ingestion, worms can be seen on the surface of the gastric mucosa, indicating that the final molting is likely to take place as the worms migrate out of the mucosa **(Sollod et al., 1968).**

- **Clinical signs**

Obeliscoides cuniculi in rabbits typically has no symptoms. In rabbits, a severe infestation can cause hemorrhagic gastritis during the first two weeks of infection, followed by anemia, anorexia, and diarrhea before the animals recover their normal state. Fecal flotation and the detection of the eggs in the feces are used to diagnose the presence of O.c.

Adult worms closely cling to the mucus lining of the stomach, it was discovered during necropsy. In the gastric crypts, some worms were discovered. Due to the interaction of larval parasites, glandular hyperplasia, and infiltration of inflammatory cells, pathological signs are confined to the stomach, with a thickened and granular ("cobblestone") mucosa **(Russel et al., 1970).**

- **Treatment**

The rabbits can be treated by benzimidazol : Fenbendazole 20mg/kg, repeated after 10-14 days and Thiabendazole 100-200mg/kg PO, nine dose regimen: one dose of 110mg/kg PO, followed by eight doses of 70mg/kg **(Watkins et al., 1984) (Schoeb, 1990).**

I.1.1.4. Infection by *Graphidium strigosum*

Disease caused by a hematophagous nematode Graphidium strigosum, a parasite of the stomach and small intestine, a cosmopolitan parasite mainly observed in wild rabbits and arctic leporids. Its presence in hare populations is related to the presence of wild rabbits (fig 11).

Figure 9: Oocyst of Graphidium strigosum.

(www.acrisah.co.kr/rabbit/rabbit5.html)

- **Life cycle**

The life cycle is monotonous, and the eggs are excreted with feces, and hatch into larvae in the external environment. Contamination occurs through ingestion of infective L3 larvae on plants. After ingestion, adults lie on the gastric mucosal surface **(RAUNIER, 2016).**

- **Clinical signs**

The disease is typically asymptomatic, severe infections can cause the gastric mucosa to be destroyed, leading to fibrosis, diarrhea, anemia, and occasionally a hemorrhagic gastritis **(BOUCHER et al., 2013) (RAUNIER, 2016).**

- **Treatment and prevention**

Graphidium strigosum does not represent a zoonotic risk, the parasitized animals can be parasitized animals can be treated with: Fenbendazole 10-20 mg/kg, MacrolideR (Ivermectin) 0, 4 mg/kg+. Hygiene measures are necessary to eliminate the infecting stages **(Wetzel and Enigk, 1937).**

I.2.2. Protozooses

I.2.2.1. Coccidiosis

The most important protozoan in a hare's diet, *Eimeria*, is responsible for parasitic diseases. Existing in 25 different species **(LOUZIS et al., 1984),** of which 11 are more prevalent in rabbits **(TAYLOR et al., 2013).**

Only three species of *E. piriformis*, *E. media*, and *E. flavescens* are found in the colon. The majority are found in the small intestine (**HENDRIX, 1998**). *E. stiedaise* grows in abundance in the liver and bile ducts (fig 12, 13).

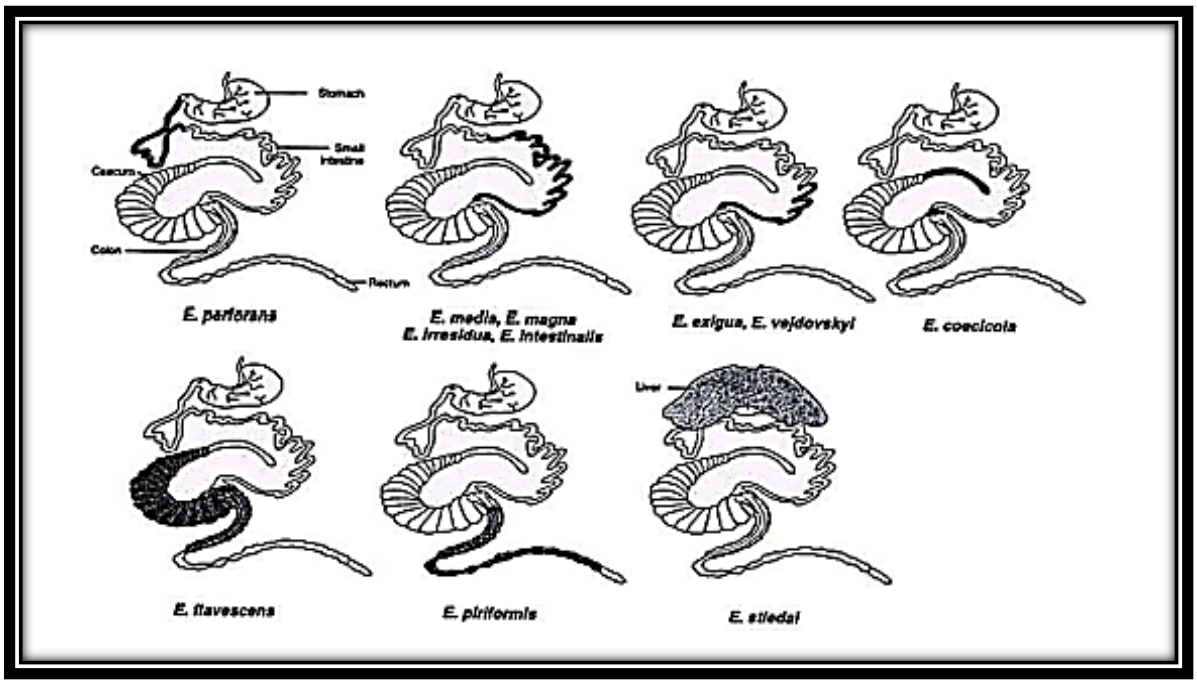

Figure 12: Location of the main Eimeria species in the digestive tract of rabbits **(TAYLOR et al., 2013).**

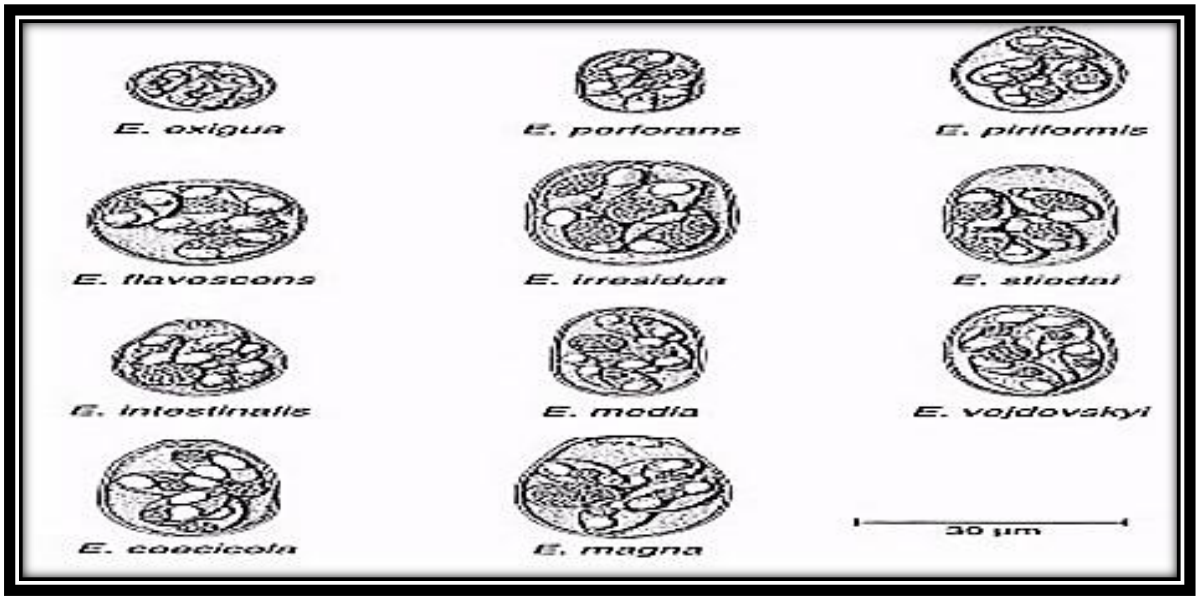

Figure 13: The various Eimeria species infecting rabbits.

(BOULADOUX, 2016).

-Pathogenicity

Eimeria intestinalis and *Eimeria flavescens* are responsible for the most severe attacks, while other species are either barely pathogenic or non-existent tab 2 **(RAUNIER, 2016).**

Table2: Pathogenicity of various coccidia.

Pathogenicity	Species	Symptoms
Non-pathogenic	*E. coecicola*	No signs of disease
Low pathogenic	*E. perforans* *E. exigua* *E. vejdovsky*	Slight drop in GMQ (average daily gain) No diarrhea No mortality
Pathogenic	*E. media* *E. magana* *E. piriformis* *E. irresidua*	Drop in GMQ Diarrhea possible Rare mortality
Highly pathogenic	*E. intestinalis* *E. flavescens*	Severe drop in GMQ Severe diarrhea High mortality

Species of Eimeria	Form	Location	Size		Residual body	Micropile	Period pre-slope	Duration of sporulation
			Length (um)	Width (um)				
E. perforans	Subspherical Ellipsoid rectangular	Duodenum jejunum	22,2±2,8	13,9±0,9	+	±	4,5	30
E. media	Ellipsoid	Duodenum jejunum	31,1±2,1	17,0±0,9	++	++	4,5	40
E.coecicola	Ellipsoid	Bulb caecal	345±2,4	19,7±0,8	++	++	9,0	90
E.magna	Ellipsoid Large	Small intestine	36,3±1,7	24,0±0,9	+++	+++	7,0	80
E.irresidua	Sub rectangular	Duodenum jejunum	35,2±1,8	21,9±1,1	-	++++	9,0	58
E.piriforis	Piriform	Caecum colon	29,5±2,3	18,0±1,2	-	++	9,0	90
E. intestinalis	Piriform Losangic	Ileum	26,8±1,7	18,9±0,9	++	++	9,0	90
E. flavescens	Ovoid Ellipsoid	Caecum colon	30,0±2,2	21,0±1,0	-	++++	9,0	80
E. steidai	Elongated Ovoid	Liver	35,7±0,4	19,9±0,5	-	±	14,0	75
E. vejdovsky	Round	Intestine	31,5	19,1	++	+	10,0	/
E.exigua	Round	Intestine	20,0	20,0	-	-	7,0	/

Table3: Morphological and biological characteristics of different Eimeria species.

(BOUCHER et al., 2013)

- **Life cycle**

Rabbits and hares cannot be parasitized by other rabbits or hares, and neither can they be parasitized by other species of coccidia because Eimeria are monoxenous and specific to their host. During the same cycle, they can reproduce sexually (by fertilization) and asexually (by simple division).

The parasite cycle includes two distinct phases: An external phase marked by the release of immature (non-infesting) oocysts into the external environment where they undergo a sporogony phase to become infective oocysts (sporulated oocysts) and an internal phase, leading to an important multiplication and excretion of oocysts **(BESSON, 2005) (BOUCHER et al., 2013).**

- **Clinical signs**

Animals under stress or those who have digestive problems linked to other pathogens are more likely to develop intestinal coccidiosis. As with all intestinal parasites, watery or even hemorrhagic diarrhea is a common symptom that causes rapid weight loss. Dehydration-related rapid weight loss, a significant weakening, and Nervous disorders may manifest at the conclusion of evolution **(BESSON, 2005).** Nervous disorders may manifest at the end of the evolution **(BESSON, 2005) (CORDIER, 2010).**

- **Treatment and prevention**

In order to prevent rabbit coccidiosis, several compounds are utilized. We will only go over the key ones here. **(FIORELLO, 2013**).Sulfadimethoxine as well as sulfamethoxine are used at 50 mg/kg at the first dose, then at 25 mg/kg once daily for 20 days. Toltrazuril is also used at a dose of 20 mg/kg as a single dose or 7 mg/kg for 2 days.

By draining the wet areas and disinfecting the ground, especially where there are accumulations of droppings, one should try to prevent the spread of coccidia in the outdoor environment as a prophylactic measure **(DECHAMBRE, 1955).**

I.2.2.2.Cryptosporidiosis

An intracellular protozoan of the genus Cryptosporidium belonging to the family Coccidia causes the emerging, opportunistic parasitosis known as cryptosporidiosis **(MEZAL et al., 2015)**.*Cryptosporidium caniculus*, a parasite of the intestine's epithelial border, can infect rabbits. The oocysts have a thick, smooth wall and are subspherical (Fig. 03). Ranging in size from 5.55 to 6.40 micrometers in length and from 5.02 to 5.92 micrometers in width. They include a residual body and 4 sporozoites **(RAUNIER, 2016).**

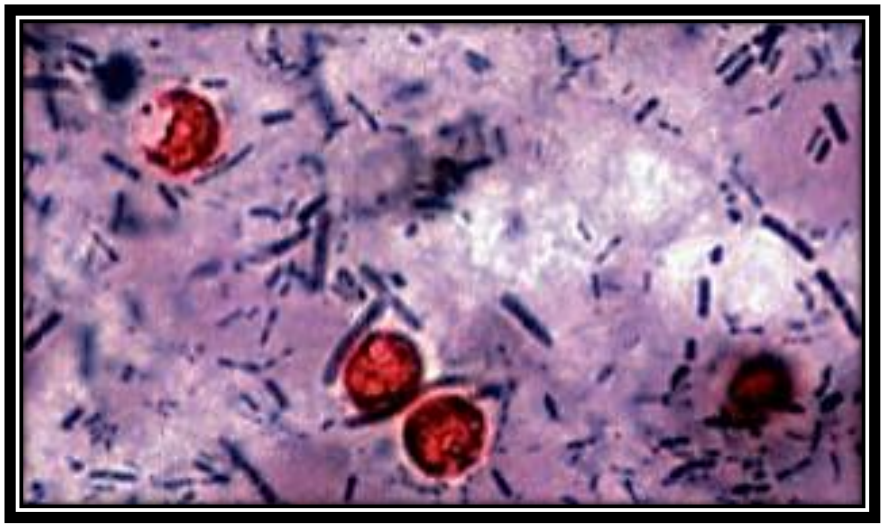

Figure 14: Cryptosporidium oocysts are non-homogeneously and irregularly stained in red irregular (GX1000)**(GUYOT and al., 2012).**

- **Life cycle**

Cryptosporidium has a monoxenous life cycle. Ingestion of sporulated oocysts found in food and water causes contamination **(RAUNIER, 2016).** In contrast to coccidia, the latter sporulate within the host or in the surrounding environment **(ABAHRI et al., 2015).** The intestinal epithelial cells are invaded by the released sporozoites. Oocysts are produced as a result of both asexual and sexual reproduction, the majority of which develop a thick double wall and are shed along with the stool, contaminating the environment, and about 20% of which have a thin wall and help to keep the infection in the host **(RAUNIER, 2016).**

- **Clinical signs**

According to **RAUNIER (2016),** infection with *Cryptosporidium cuniculus* in adult rabbits is frequently asymptomatic, but in 20–80 day old rabbits, anorexia, dehydration, and diarrhea may occur.

- **Treatment**

No known treatment for rabbits infected with Cryptosporidiosis exists, accordingto **RAUNIER (2016),** and according to **BOUCHER et al. (2013),** no treatment has demonstrated its efficacy. However, some medications that have been tested on people can also be used on rabbits, including spiramicin and erythromycin.

I.3. External Parasitic Diseases

II.3.1. Scabies

Different protozoa from species of non-burrowing and burrowing mites cause the emerging and highly contagious disease scabies in rabbits **(Perrucci et al., 2005).** Several skin conditions, including psoroptic, sarcoptic, and notdric mange, are brought on by mites in rabbits **(Sharma et al., 2018).**

Sarcoptes scabiei var.cuniculi (scabies of the body and head), *Psoroptes cuniculi* (ear scabies), and *Cheyletiella parasitovorax* are ectoparasites that can cause mange in rabbits**(Elshahawy et al., 2016) (Panigrahi et al., 2016).**

Figure 15: Ear scabies or otacariosis

(BOUCHER and NOUAILLE, 2002).

Figure 10: Scabies of the body and head

(BOUCHER and NOUAILLE, 2002).

- **Life cycle**

The host can become infected by the parasite's adults, nymphs, and larvae. The mites can also detect the host's odor and temperature **(Hicks and Elston, 2009).**Due to their high pathogenicity, the larvae infest the healthy host by coming into direct contact with their skin within 20 min. More than a month passes through the entire life cycle **(Suckow et al., 2002).** Females produce hypersensitivity, inflammation, and skin rashes as they lay their eggs in tunnels in the stratum corneum of the skin. The larvae emerge from the egg after 3 to 10 days, crawl across the skin in search of hair follicles, molt, and finally develop into adult mites. Adult mites remain in the host's skin for 3 to 4 weeks.

- **Clinical signs**

Scabies is characterized by pruritus, alopecia and prolonged illness with severe cachexia **(Choe et al., 2020),**associated with vestibular dysfunction and meningitis**(Ulutas et al., 2005).**

As a result of the parasite feeding on the granular layer of the epidermis and the animal's serum, pruritic and cutaneous lesions develop **(Mc et al., 2004).**After a mite infestation, blood loss and frequent complications from secondary bacterial infections are to be anticipated **(Shang et al., 2014)(Zakrzewski et al., 2014).**

- **Treatment and prevention**

Utilizing particular parasiticides or acaricides could result in the effective treatment of mange in rabbits. The most widely used acaricides are organophosphorus substances (like diazinon), synthetic pyrethroids (like permethrin and delamethrin), and macrolactones (derivatives of ivermectin). The group of avermectin derivatives consists of ivermectin **(Sharun et al., 2019) (Curtis et al., 1990) (Niaz and Shoaib, 2015),** eprinomectin **(Pan et al., 2006) (Ulutas et al., 2005) (Wen et al., 2010),**doramectin **(Singari et al., 2001) (Kaya et al, 2010)**, selamectin **(McTier et al, 2003) (Farmaki et al., 2009),** moxidectin **(Hansen et al., 2005)** and abamectin **(Wagneret al., 2000)**.

Scabies can also be treated with benzyl benzoate, carbamates, sulfur compounds **(Rock, 2007) (Abdelaziz et al., 2020)**and kerosene oil **(Niaz and Shoaib, 2015).**

-Contact with a contaminated rabbit should be avoided.

-Avoid domestic rodents and rabbits in general.

-Regular cleaning of cages or environment.

-Isolation of affected animals, but if this is not possible, treatment of the whole herd is necessary **(BOUCHER and NOUAILLE, 2002).**

I.3.2. Flea infections

The common myxomatosis vector, the rabbit flea (*Spillopsyllyus cuniculi*), is found on pet rabbits. Rabbits living with dogs, cats, or on infested property can also contract the cat flea (*Ctenocephalides felis*) and dog flea (*Ctenocephalides canis*) **(Varga, 2014).**

-Life cycle

Fleas consume 15 times their body weight in blood each day as they feed on the blood of their host. They can lay up to 50 eggs per day, making them extremely prolific breeders. The flea life cycle has four stages: egg, larva, pupa, and adult. The duration of the entire life cycle will range from two weeks to several months. Fleas can quickly multiply into significant population sizes in the environment under warm, humid conditions and in the presence of enough hosts. The eggs can stay dormant until the conditions are better if it's cooler and dry. This is why it can be difficult to manage a flea population **(Kraus et al., 1984).**

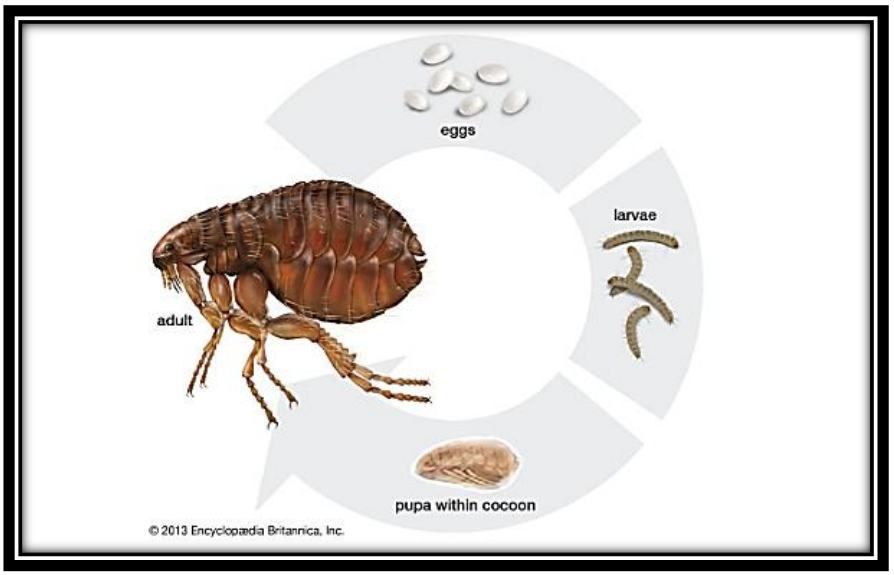

Figure 17: Life cycle of fleas**(https://www.britannica.com/animal/flea/Natural-history#ref256630)**

- **Clinical signs**

Intense scratching brought on by flea infestation causes a dull, uneven coat, spots where fur has lost, erythema, and scabs in rabbits. By checking the coat for fleas and flea dirt, the condition can be quickly identified. Hair loss along the back associated with a flea allergy dermatitis can also happen **(Varga et al., 2023).**

- **Treatment and prevention**

Effective treatments include imidacloprid (Advantage 40, Bayer), selamectin (Stronghold, Pfizer), and lufenuron (Program). Selamectin does not have a long-lasting residual effect in rabbits, which could compromise control **(Varga et al., 2023).**

In the overall flea control strategy, environmental treatment is crucial because it targets the eggs, larvae, and cocoons that make up 95% of the flea population. This is achieved by eradicating the adult forms using adulticides, neurotoxic adulticides, and by eradicating the immature forms by combining growth regulators with hygienic measures **(Bouhsira et al., 2015).**

I.3.2.3. Lice infections

A rare report of the *O. cuniculus* louse, *Haemodipsus ventricosus*, in domestic rabbits has been made **(Paterson, 2006).** According to **Durden and Rausch (2007)** and **Schoeb et al.**

(2007), other *Haemodipsus* species infest other rabbit species. With the naked eye, one can see the organism and its eggs.

- **Life cycle**

The host is where the eggs are laid, and they are firmly fastened to the hair. Their distinctive operculum, from which the larvae emerge, gives them an oval shape. The young go through three ecdyses, or moults, before becoming adults, and they are similar to the adult. Depending on the environment, the entire life cycle takes 2 to 5 weeks **(Varga et al., 2014).**

- **Clinical signs**

Infested rabbits may exhibit pruritus, erythema, papules, alopecia, and also anemia. *Francisella tularensis*, which causes tularemia, can also spread through lice **(White et al., 2002) (Palmeiro and Roberts, 2013).**

- **Treatment and prevention**

Lice can be prevented with similar treatments to fleas, ivermectin (0.4 mg/kg, q14d). Likewise, treating the environment with an approved environmental insecticide that is safe for rabbits can minimize range and persistence intrusion **(Laurie and Kathy, 2012).**

Experimental part

Chapter II: Material and methods

The main aim of our study was to estimate the prevalence of gastro-intestinal parasites and ectoparasites in rabbits from two breeding systems in different localities from Djelfa region.

II.1. Description of the study area

Our study was carried out during a period of 4 months (from February to May 2023) in different localities locatedin the region of Djelfa, including the city center, Faidh El Botma, Marqab Bin Hafaf, Hassi Bahbah, Reguiba, and Ain Oussara (fig 18).

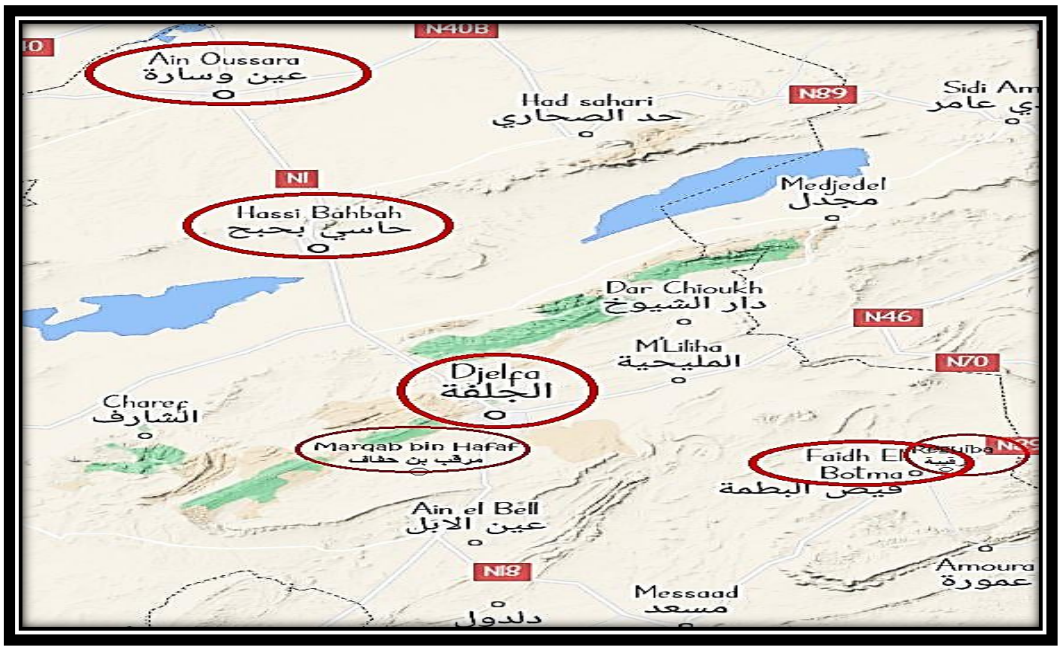

Figure 18: Map showing of the different localities from Djelfa region, included in the present study **(GOOGLE MAP, Original, 2023).**

The region of Djelfa is located in the central part of northern Algeria. The capital of the province is 300 km south of the capital Algiers. It is located between 2° and 5° East longitude and 33° and 35° North latitude. Its total area is 32,256.35 km², representing 1.36% of the total area of the country. The population is estimated at 1,475,000 inhabitants, i.e. a density of 47.1 inhabitants/km^2 (**D.P.S.B, 2020**).Djelfa is a semi-arid (center and north parts) to arid (south part) region, characterized by a dry climate with hot and dry summers and cold winters. Periods of very strong frost characterize the winter seasons (**KOUSSA and BOUZIANNE**, **2018**).

II.2. Population of studied rabbits

II.2.1. Description of sampled farms and examined rabbits

10 farms were sampled from the six visited localities where each farm was visited from each locality; except in city center of Djelfa, five farms were visited. 120 fecal samples of domestic rabbit were collected during the study period from these 10 farms. Sampled rabbits belonged to traditional and rational farms. The different information's recorded for the sampled rabbits are summarized in the tab 4.

On each farm we found almost all of the species below:

Table 04: Recorded informationonrabbits examined in the present study**(Original, 2023)**

Breed	Size	Weight (kg)	Color dander	Dander condition	Total number of sampled rabbits
Flemish rabbit	**Normal/ Giant**	**15 – 22**	**-Grey + white -White -Brown**	**Good**	(16)**13,33%**
Angora rabbit	**Giant**	**4,4 – 6,6**	**White**	**Good**	(14) **11,67%**
Himalayan rabbit	**Giant**	**6 – 8**	**White with points of either black**	**Good**	(12) **10%**
Checkered rabbit	**Giant**	**11 – 25**	**-Black + White**	**Good**	(13)**10,83%**
Chinchilla	**Mini/ Giant**	**7 – 12**	**-Dark grey**	**Good**	(5) **4,16%**
Netherland Dwarf rabbit	**Mini**	**1,1 - 2,5**	**-Black + White**	**Good**	(14) **11,67%**
Californian rabbit	**Giant**	**7,5 – 9,5**	**-White - Grey + white**	**Good**	(20) **16,67%**
Californian rabbit cross	**Giant**	**9 – 10,5**	**-Black + White**	**Good**	(17) **14,17%**
Rex rabbit	**Giant**	**6 – 10,5**	**-Brown+ White -Black + White**	**Good**	(9) **7,5%**

II.2.2. System of breeding

II.2.2.1.Rational breeding

Eight farms that adopted the rational breeding belonged to the localities city center, Faidh El Botma, Marqab bin Hafaf and Hassi Bahbah. Rabbits were housed in structures with openings that permit ventilation and natural light (sunlight), as well as the provision of artificial light. Heating was also provided by the majority of the aforementioned stations. Rabbits were housed in metal cages where each cage encompasses one to three individuals. Newborn cages are wooden, fully enclosed with straw-lined litter and an opening that serves as a door.There were anywhere between five and seventy cages for each farm.

Figure 19: Cages of rabbits from rational farms **(Original, 2023).**

Regarding the feed and watering system in these farms, a commercial granulated food was offered to all rabbits one time each day. Thisgranulated food comes in three varieties including feed for mother rabbits, for fattening, and for growth (fig 20).This granulated food contains soybean meal, soybean oil, phosphates, calcium, acids amines, and otheroglio elements Luzern, folic acid, poly vitamins, and antioxidants.

Figure 20: Rabbit feed (orange for mother rabbits,red for fattening,and green for growth) **(Original, 2023).**

The water supply was provided by a spring that is manually filled, and the watering is done by a nipple system that is connected to elevated tanks.
Concerning the reproduction, at the age of four months, the females are first introduced to the males, taking into account their average weight of 2800 g at this age. The females are mated 12 days after giving birth, according to a semi-intensive rhythm of natural reproduction. Between the 10th and 12th day following the mating, abdominal palpation is used to diagnose the pregnancy. Non-pregnant Females are immediately re-sired. Those rabbits that are sick or won't breed are slaughtered. The rabbits are bred to the same males during the three successive cycles in order to prevent the male effect on their performance.
With the addition of sawdust (total born, live born, and dead born), the nest boxes are placed on the 27th day of mating, and all of these information are recorded. Each doe has an average of six young rabbits. Homogenization was carried out when there is a high deviation. The young's are weaned at 33 days of age. Following weighing, they are moved to cages for fattening.

Figure 21: Young rabbits **(Original, 2023).**

Regarding the application of hygiene and prophylactic measures in these rational farms, cleaning and disinfection of the floor, cages, feeders, drinkers, and the nesting boxes, as well as the supports of the cages were done daily to maintain the cleanliness of the breeding building. Once every 15 days, the cages are passed through a blowtorch to remove hairs as the final step in cleaning.Some antiparasitics drugs have been used preventively, including for example:

- Ivermectin against ectoparasites (used once every 3-4 months).
- Albendazol (used once every 3-4 months).
- Coglavax (vaccine) against enterotoxaemia.
- Cunipravac against viral hemorrhagic disease also called VHD (used once every 6 months).
- Vinegar is added to the drinking water to reinforce the immunity.
- Once a year, a sanitary vacuum is practiced.

II.2.2.2. Traditional breeding

Two farms that adopted traditional breeding belonged to the localities of Reguiba and Ain Oussara**.** The farms are rooms where rabbits live free outside their cages in the morning and bring them back in the night. Open spaces with openings for ventilation and light are available. Food and drinks are served on plates and the floor is covered with sawdust.

Figure 22: Traditional building **(Original, 2023).**

Similar to the rational farms, these farms provide a pellet feed. In addition, hard bread, straw, and some carrots are given to rabbits.

Regarding the reproduction, four days after farrowing, the mating is starting. After about 10 days of mating, the breeder puts the rabbit back in the male's cage to diagnose her physiological condition; the male's acceptance or rejection of her indicates whether the mating was fertile. The weaning of the rabbits begins at 25 days and lasts until they are 34 days old. They are isolated in small, individual cages, and are typically sold or kept for personal consumption.

Regarding the application of hygiene and prophylactic measures in these traditional farms, onlythe rooms where rabbits live are cleaned once per week and the drinking water is infused with vinegar.

II.3. Sampling techniques

II. 3.1. Collect of feces

The collection of fecal samples was performed during the period of February to May 2023.The feces were collectedevery Sunday morning,directly from the rectum of the rabbits or immediately after defecation, and then they were put in sterile pots and transported to the laboratory in a cooler for coproscopic analysis.An information sheet (date of sampling, age, sex, state of health) was established for each sampled rabbit (Fig 23).

Figure 23: Collect of fecal samples **(Original,2023).**

II.3.2. Research and collect of ectoparasites

The research of ectoparasites was performed in the different parts of the body of rabbits (head, back, legs....etc.). Forceps were used to manually remove possibly present parasites from the rabbit's body (fig 24).

Figure 24: Research and collect of ectoparasites from rabbit's body **(Original, 2023)**.

II.4. Analysis methods

II.4.1. Macroscopic observation of fecal samples

The macroscopic examination was done with the naked eye or with a magnifying glass (fig 25). It allows an appreciation of the physical qualities of the samples such as the consistency (diarrhea, constipation), color (presence of blood or not, pigments), presence of mucus, and presence of food debris It's a simple and inexpensive technique. In addition, this exam allows macroscopically observation of the obvious parasite components such as adult worms **(EUZEBY, 1981).**

Figure 25: Macroscopic examination of fecal samples**(Original, 2023).**

➢**Laboratory materials**

- Specimen containers (droppings);
- Spatula;
- Pestle and mortar;
- A scale;
- Gloves;
- Plastic pipettes;
- Tea strainer (2);
- Graduated glassware: Becher - test tubes;
- Microscope slides, coverslips;
- A microscope equipped with objectives: x4, x10, x40, and x100;
- Immersion oil;
- 0.45µm porosity filters.

➢ **Reagents:**

- Pure methanol;
- Ziehl-Neelsen carbol fuschin solution prepared as follows:

*15 g of basic fuschin powder mixed with 100 ml of 95% ethanol..... (Solution 1).
*5 g phenol mixed with 100 ml distilled water..... (Solution 2).
*To prepare 100 ml of the solution, mix 90 ml of solution 2 with 10 ml of solution 1. The reagent is then allowed to homogenize, and filtered through filter paper.

- 5% malachite green: 5g malachite green + 100ml distilled water.
- 2% sulfuric acid: 4ml sulfuric acid (96%) + 196ml distilled water.
- A dense solution of NaCl.

II.4.2. Microscopic examination of fecal samples

Two methods were used to analyze the collected samples. The flotation technique was used for the detection of helminthes eggs and the oocytes of certain protozoa.The modified Ziehl Neelsen staining technique was used for the detection of *Cryptosporidium spp.*

II.4.2.1. Flotation technique

Flotation is the most used enrichment technique in veterinary medicine. Its principle is based on the difference in density of the faecal debris, parasitic elements and the used solution. It is effective to have the maximum of parasites especially of weak density like theprotozoa and helminthes eggs.

Table05: Benefits and disadvantages of the flotation method **(LUSSOT et al., 2008).**

Benefits	Disadvantages
Very good sensitivity (++++)	Deformation of parasitic elements
Easy	No evidence of heavy eggs for solutions of density <1,30
Fast	Not very suitable for larvae research
Low cost	/

Using a liquid with a higher density than the parasite eggs, the flotation enrichment approach causes the detritus to fall to the bottom while the parasite eggs float to the surface. The ability to recognize eggs is more sensitive when the liquid is denser**(BEUGNET, 2000).**However, a liquid with high gravity also lead particles to rise to the surface, making the difficulty of the microscopic examination**(O'GRADY and SLOCOMBE, 1980).**

➢ **Protocol**

To carry out the flotation technique, we followed the following steps:

- Put the fecal sample in the mortar using a pestle.
- Dissolve the fecal sample matter in a dense solution of NaCl;
- Filter the mixture through a tea strainer into a beaker;
- Fill test tubes with filtered liquid;
- Cover the tubes with a coverslip, avoiding the formation of air bubbles,
- Leave to stand for 15 to 20 minutes.
- Remove the coverslips and place on a slide;
- Microscopic examination of slides at G×100 and G×400.**(Richard, 2012)**

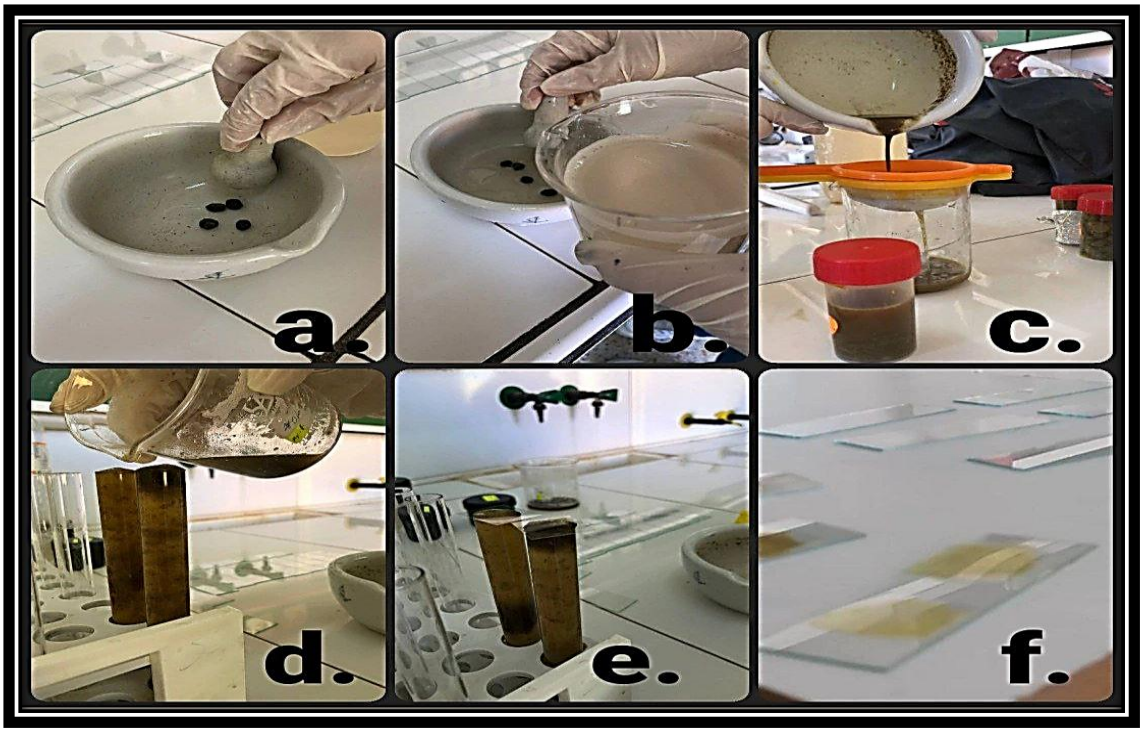

Figure 26: Different stepsof the flotation technique **(Original, 2023).**

➢Used material

-Flotation solution: NaCl (density = 1.2%);
-Strainer;
-Balance;
-Graduated glass;
-Fresh stools;
- Mortar;
-Test tubes;
- Slides and coverslips;
- Optical microscope.

II.4.2.2. Modified Ziehl-Neelsen staining technique

This method is a specific technique for staining of Cryptosporidium oocysts. This technique has benefits such the simplicity and readability. Its main drawback is the poor sensitivity **(Henriksen and Pohlenz, 1981).**

- **Ritchie technique:**

-Dilute 1 volume of stool in 10 volumes of Ritchie's reagent (100 mL of formalin, 9g of NaCl, and 900 mL of distilled water);
-Mix and let sediment for a few seconds;
-Transfer to a centrifuge tube;
-Add ether (flammable): 1/3 ether to 2/3 mixture;
-Stopper and mix by inversion for 30 seconds;
-Centrifuge 2 min at 1500 rpm;
-Remove the supernatant by inversion;
-Perform a direct examination on the centrifugation pellet.**(Hamouda, 2020)**

➢ Protocol and material

-Making a smear: a drop of the pellet obtained from the simplified Ritchie technique is pipetted on a well-degreased slide. Then, using another slide, the drop is spread along the slide.
- Leave the smear to air-dry;

- Fix the smear with methanol for 5 minutes and dry again;
- Stain the slide with the fuschin of Ziehl for 1 hour;
- Rinse the slide under tap water;
- Differentiate the slide with 2% sulfuric acid for 20 seconds;
- Rinse the slide under tap water;
- Stain the slide with 5% malachite green for 5 minutes;
- Rinse again the slide and leave it to air dry.
- With immersion oil, the stained smear (slide) is examined microscopically at magnification of x400 and x1000.

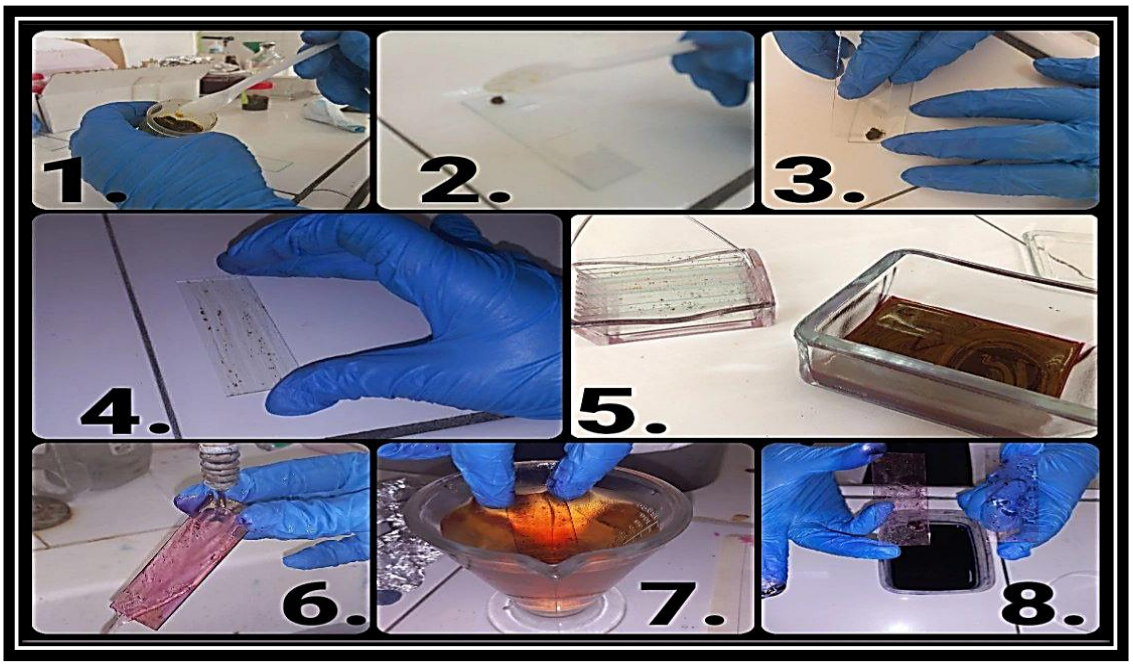

Figure 27: Different steps of theZiehl-Neelsen staining technique**(Original, 2023).**

Chapter III:
Results

III. Results

A total of 120 fecal samples were collected in nine sites from the six localities, previously described. Fecal samples were analyzed macroscopically as well as using parasitological techniques.

III.1. Results of the macroscopic examination of fecal samples

The physical characteristics of collected feces are indicated in the tab 06. We were able to note for each sample the consistency, appearance, color, and the presence of mucus.

Table 06: The physical characteristics of feces from domestic rabbits reared on both rational and traditional farms (**Original, 2023).**

	Consistency	Color	Mucus	Aspect	Presence ofnon-specific rabbit parasites
Rational breeding	Hard/soft/ diarrhea	Brown dark/light	+	Round / elongated	+
Traditional breeding	Hard/soft/ diarrhea	Brown dark/light	-	Round / elongated	+

In both types of breeding, the macroscopic examination of fecal samples revealed dark or light brown color, and a hard, soft, or diarrheal consistency. Animals raised in the rational farms exhibited mucus more frequently in feces. Also, we observed some rather large, clearly visible non-specific rabbit parasites in the feces. We used a binocularmagnifier to closely examine these parasites. According the breeders, these parasites were a result of the vinegar that was added to the feed of rabbits.

Figure 30: Presence and contamination of feces bynon-specific rabbit parasites **(Original, 2023).**

III.2. Results of the microscopic examination of fecal samples

Following a macroscopic inspection of feces, a microscopic examination was conducted using two techniques, including the flotation technique to identify the parasite genus/species and the modified Ziehl-Neelsen staining technique for detection of *Cryptosporidium* spp.

III.2.1. Microscopic observation

The different parasitic types identified in our study were photographed under the microscope using magnification of 400 and 1000.

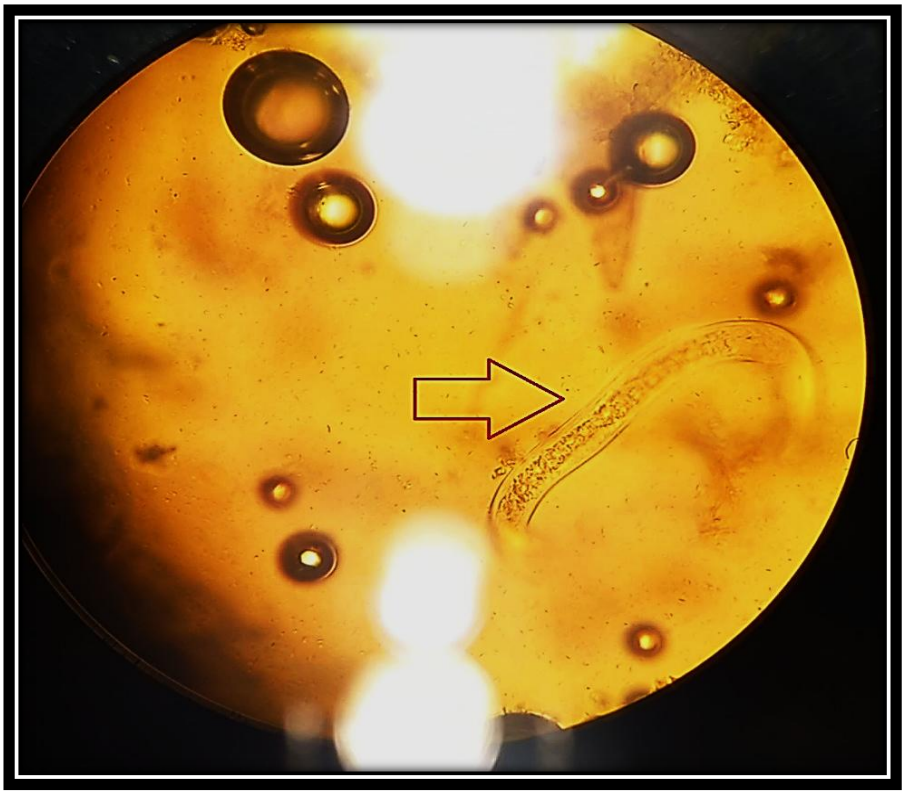

Figure 31: A nematode larvae observed under light microscope using the flotation method (Gx400) **(Original, 2023).**

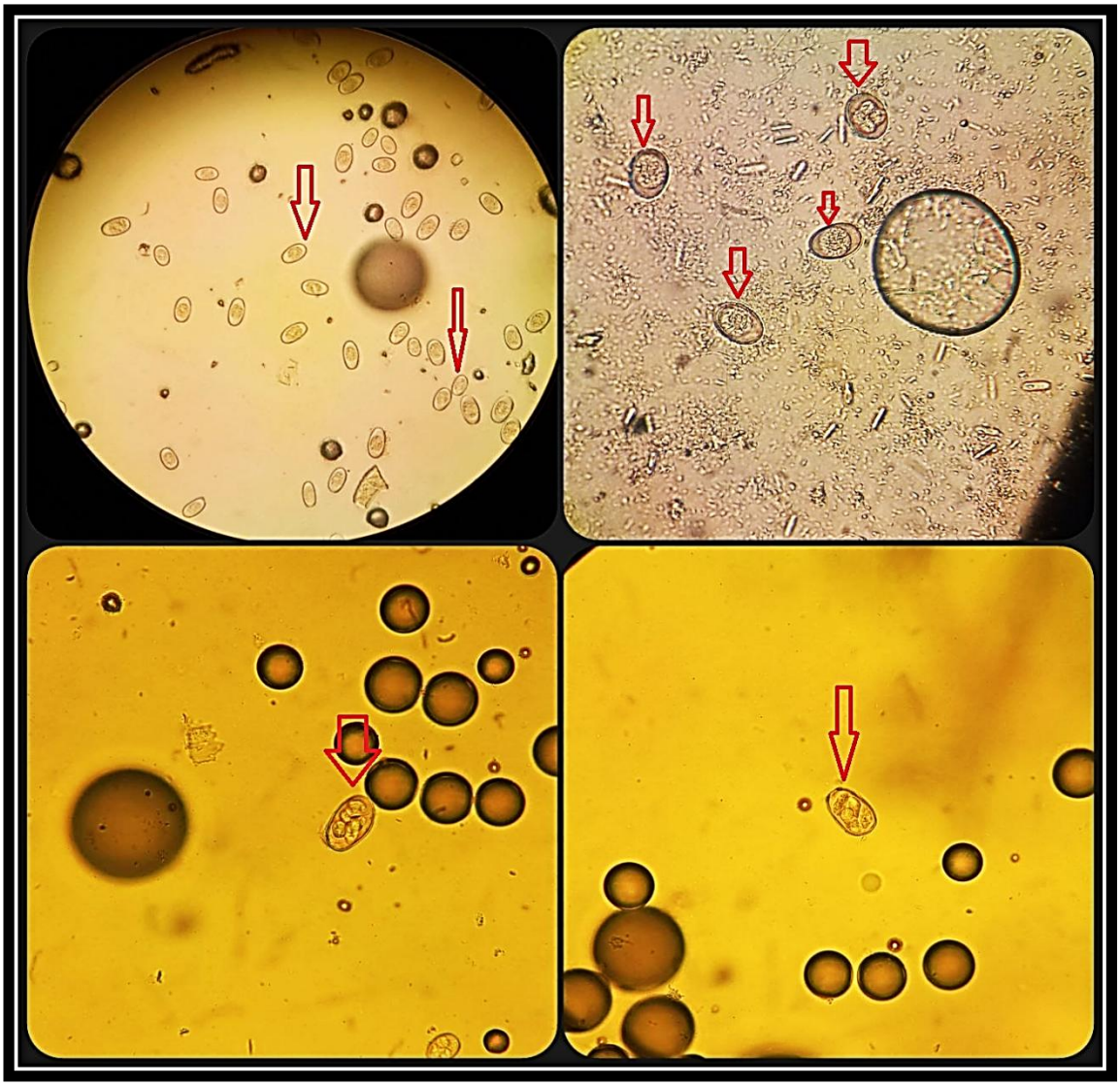

Figure 32: Oocysts of *Eimeria* spp. observed under light microscope using the flotation method (Gx100 and Gx400) **(Original, 2023).**

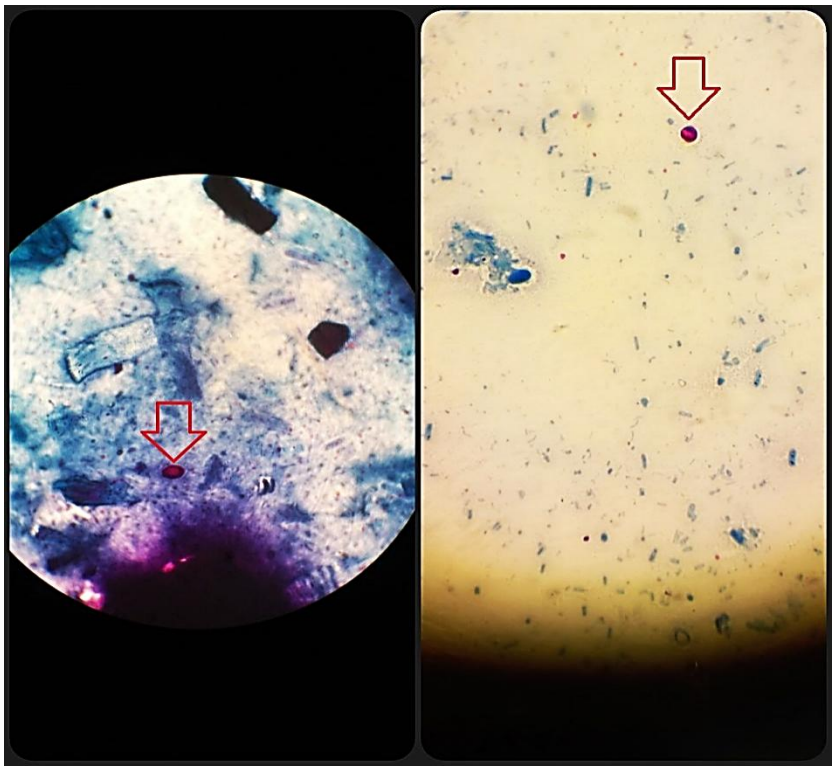

Figure 32: Oocysts of *Cryptosporidium* spp. observed under light microscope using the modified Ziehl-Neelsen staining (Gx1000) **(Original,2023).**

III.2.2. Prevalence of infestations

III.2.2.1. Global prevalence

Among 120 examined fecal samples, 52 rabbits were microscopically negative, while 68 (57%) rabbits showed an infestation at least by one parasitic type.

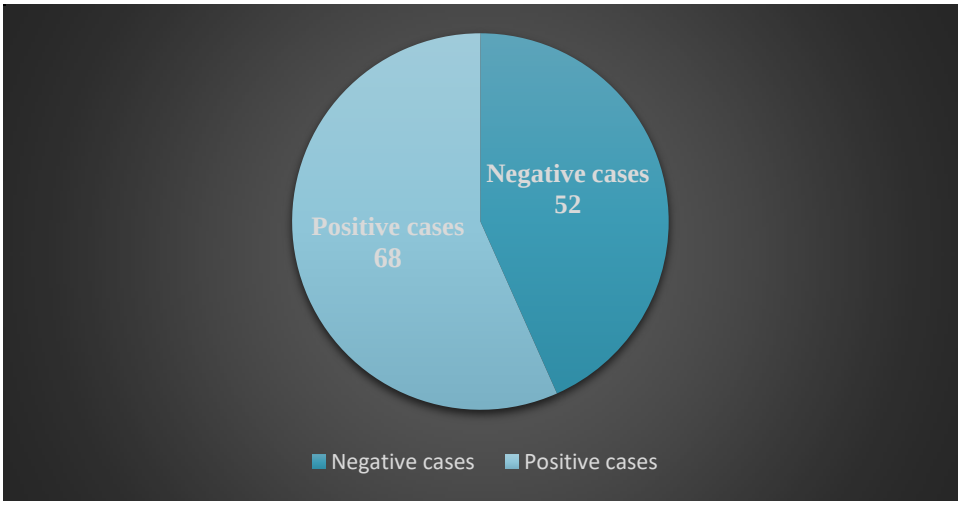

Figure 33: Overall infection rate by the different types of parasites.

III.2.2.2. Global prevalence according associated risk factor

a) Sex

Among the 74 examined females, 45(60.81%) showed an infestation, while out of 46 examined males, 23 (50%) were infected (table 08). Females showed a high infection rate as compared to males.

Table 08: Global prevalence of identified parasites according to sex

	Males	Females
Number of examined rabbits	46	74
Number of infected rabbits	23	45
Prevalence (%)	50%	60.81%

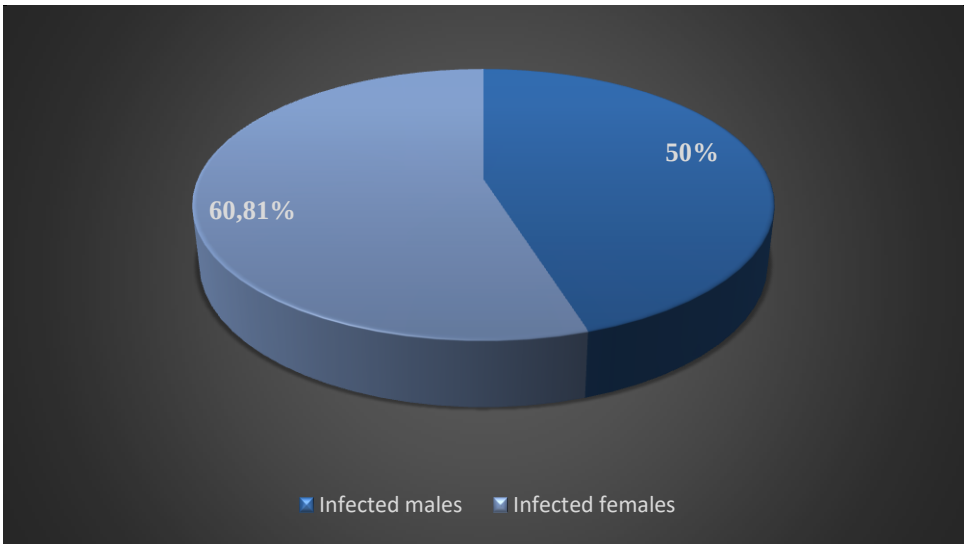

Figure 34: Overall infection rate according sex of rabbits**.**

b) Age

Based on the ability of rabbits to reproduce, consume food, and wean, three age groups are considered. The first group includes rabbits from birth to 2 months. The second group includes rabbits from 3 months to 9 months and the last group includes rabbits aged more than nine months. The overall infection rate for each group is indicated in the tab 09. Rabbits aged between 3 and 9 months and those aged more than 9 months showed the highest infection rates.

Table 09: Global prevalence of identified parasites according to age

	< 2months	3months-9months	> 9months
Positive rabbits (%)	8 (38%)	51 (69%)	17 (68%)
Negative rabbits (%)	13 (62%)	23 (31%)	8 (32%)
Total of examined rabbits	21	74	25

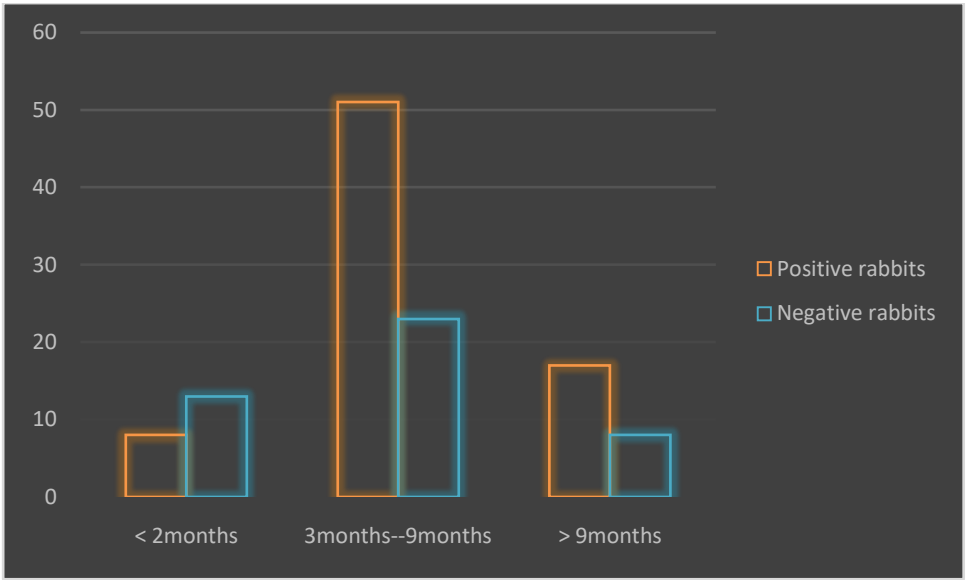

Figure 35: Overall infection rate according age of rabbits**.**

c) Type of breeding

Among the 120 examined samples, 97 rabbits belonged to rational breeding, while 23 rabbits belonged to traditional breeding. An infection rate of 15.83% and 40.83% were recorded in the traditional and rational farms, respectively (table 10).

Table 10: Global prevalence of identified parasites according to breeding system

	Rational breeding	Traditional breeding
Positive rabbits	**49 (40.83%)**	**19 (15.83%)**
Negative rabbits	**48**	**4**
Total of examined rabbits	**97**	**23**

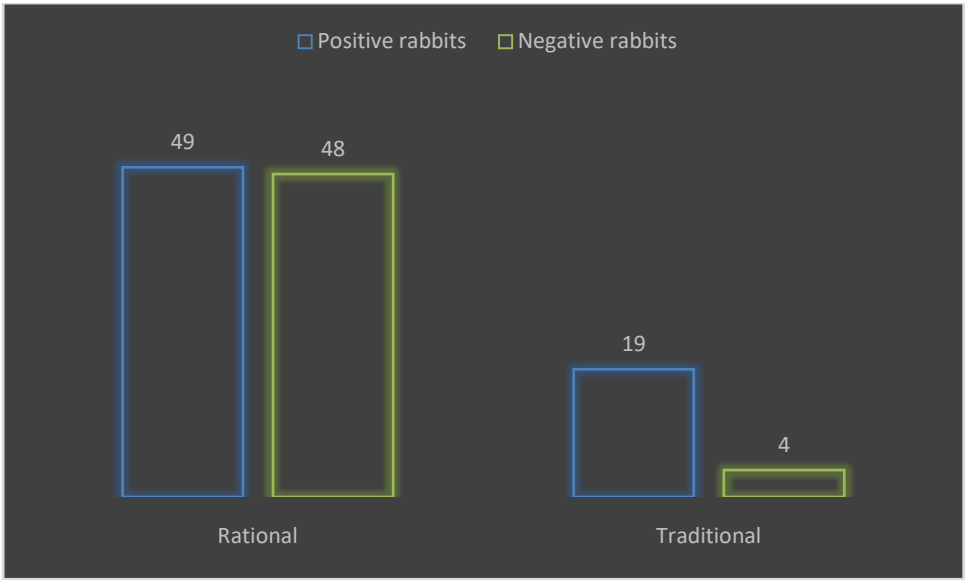

Figure 35: Overall infection rate according breeding system.

d) Nature of feces

Among the 120 examined samples, 97 sampled rabbits showed no diarrhea (solid feces) at time of sampling, while 23 rabbits showed diarrhea. Diarrheic rabbits showed high infection rate (87%) as compared to no diarrheic rabbits (49.5%).

Table 11: Global prevalence of identified parasites according to presence or absence of diarrhea

	Presence of diarrhea	Absence of diarrhea
Positive rabbits	**20 (87%)**	**48 (49.5%)**
Negative rabbits	**3(13%)**	**49(50.5%)**
Total of examined rabbits	**23**	**97**

e) Region

The number of infected rabbits in each locality is indicated in the table 12 and figure 36. The highest number of positive cases was observed in the farms from Djelfa city. Faidh El Botma locality showed only one positive case, while no infected rabbits were recorded in the farm from Reguiba locality. Taking consideration the number of farms in each locality where one farm was sampled in each locality, except in the Djelfa city, 5 farms were examined, Ain Oussara and Hassi Bahbah showed the highest number of infected rabbits because there was one sampled farm for each locality, in which the number of infected rabbits was 18 and 8 cases, respectively.

Table 12: Distribution of infected rabbits according to localities

	Djelfa city	Ain Oussara	Hassi Bahbah	Marqab bin Hafaf	Faidh El Botma	Reguiba
Total nbre of examined rabbits	**59**	**21**	**10**	**10**	**18**	**2**
Positive cases	**34**	**18**	**8**	**7**	**1**	**0**
Negative cases	**25**	**3**	**2**	**3**	**17**	**2**

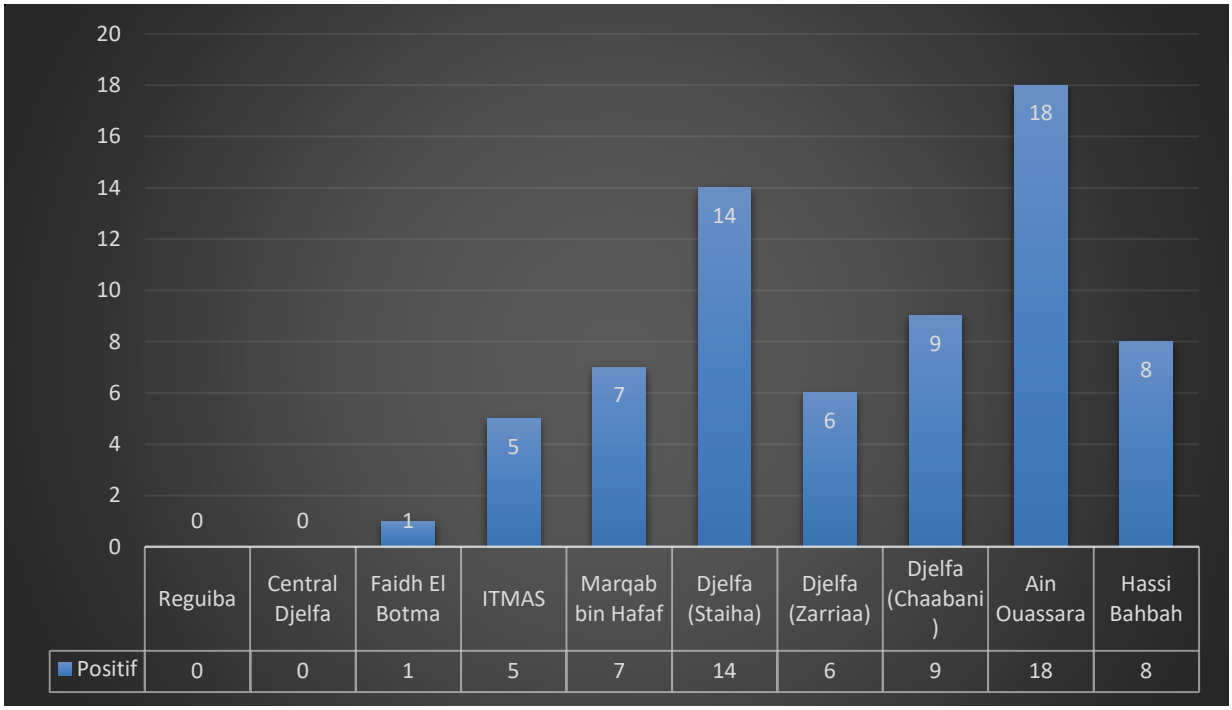

Figure 36: Number of positive rabbits in the different studied localities.

III.2.2.3. Prevalence of identified parasites

a) Prevalence of *Eimeria* spp.

Among 120 examined samples, *Eimeria spp.* was detected in 64 (53.33%) rabbits.

b) Prevalence of *Cryptosporidium* spp.

Out of 120 examined samples, 3 rabbits were tested to be positive for *Cryptosporidium* spp.

c) Prevalence of nematode larvae

Out of 120 samples, only one rabbit was found to be infected by the larva of nematodes.

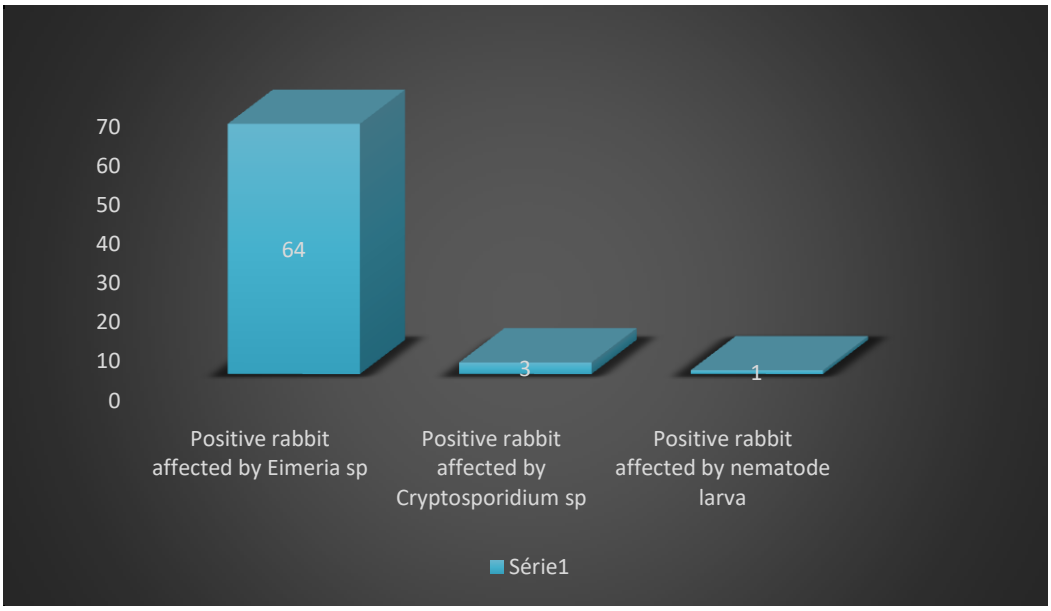

Figure 37: Infection rates of the different identified parasites.

d) Prevalence of mixed infections

Three rabbits showed a mixed infection (*Eimeria sp. + Cryptosporidium sp.)*(*Eimeria sp.* + nematode larvae), with an estimated prevalence rate of 2.5 %.

III.3. Result of the infection by ectoparasites

All rabbits showed no infection by the ectoparasites during observation exam of their body.

Chapter VI:
Discussion

Discussion

In our research based on the search for gastrointestinal parasites and ectoparasites in domestic rabbits *'Oryctolagus cuniculus'* belonging to two types of breeding (rational and traditional) conducted in the region of Djelfa, we were able to identify three species, namely:
Eimeria sp with a frequency of 53.33% and Cryptosporidium sp with a frequency of 2.5%, also the existence of a nematode larva with a frequency of 0.83%. The prevalence of these gastrointestinal parasites varies significantly between studies. This variation is related to various factors, some of which are host-related and others to sampling and rearing circumstances.

In this context, according to **AMRIOUI and KHELIF (2016**), 17 species of endoparasites and ectoparasites have been identified in farmed domestic rabbits, including:
Eimeria sp., Passalurus ambiguus, Aspicularis tetraptera with a prevalence of 100% followed by *Chilomastix sp., Trematoda sp. and Cestoda sp.,* with 80%, comes next *Balantidui sp.,* with 60%, and *Stronyloides sp.,* with 40.10%, finally *Acaria sp., Syphacia obvilata* and *Insecta sp.* with 20%. The collection of rabbit excrement was done collectively a period of four months; among the 120 examined rabbits. These circumstances account for the discrepancy between the number of species found in our results on the one hand, and the frequencies of the corresponding species (*Eimeria sp.,* nematodes) on the other, which reported a high prevalence rate of *Eimeria spp.* with the most predominate parasite.

Our findings are consistent with other Algerian studies mentioned by **Maziz et al. (2018)**with **40%** prevalence of *Eimeria sp.,* and **Bachene et al. (2019)** with 59.5 % as the highest rate**.**

Additionally, **AMIR and BELKHIR (2015)** captured 14 species, including Eimeria sp., which has a frequency of 58, 33%.
Likewise, **Abahri and Boutrik (2015)** with 19%, **Djebouri and Naami (2017)** with 85.41%, **Aissiouene and Medani (2017)** with 28.57%, **Dahmani and Kessal (2018)** with 32.65%.

Infection with *Eimeria spp.* is widespread in rabbit farms throughout the world, and most studies have noted that these coccidia predominate over other parasite species **(Farougou et al., 2004).** An important factor promoting the growth of coccidia in farms is poor management, such as unsanitary conditions.

Similar to our findings, some studies **(Boucher and Nouaille, 1996; Farougou et al., 2004)** reported low prevalence rates of gastrointestinal helminthes rates with 5.4%.

In contrast to Eimeria spp., some studies have found a higher prevalence of specific helminth species (nematodes) **(Sebila, 2008).**The dominance of one species over another can be influenced by a variety of factors, including the breeding process and the feeding environment (type of food provided).

Low prevalence of *Cryptosporidium spp.* was also discovered. Compared to our findings, some studies from Algeria and Nigeria reported high prevalence rates of Cryptosporidium, **Mezali et al., (2015)** with 83, 33%, same as **Ayinmode and Agbajelola (2018).** Numerous studies reported low prevalence rates, which are consistent with our findings **(Chalmers, 1996; Fang et al., 2007; Robinson et al., 2010)** rates with 0%, identical to what has been shown in some studies from Germany and Tunisia **(Epe et al., 2004; Soltane et al.,**

2007). Compared to cryptosporidiosis in ruminants, the epidemiology of cryptosporidiosis in rabbits is poorly understood. Consequently, a lack of data makes it challenging to comprehend the factors influencing the variation in prevalence rates between studies.

In fact, **BADR and BORKOVCOVA (2005)** found seven species of endoparasites and five ectoparasites species in a survey of wild rabbits in eastern Bohemia, including *Graphidium strigosum, Passalurus ambiguus, Trichostrongylus retortaeformis, Eimeria sp., and Taenia pisiformis.*

In Poland, a study by **KRZYZTOF et al. (2014)** found that from 2007 to 2011, in slaughtered rabbits from farms or industrial farms, three groups of species were isolated with a variety of frequencies: coccidia (78.83%), nematodes (16.42%), and tapeworm (0.72%). This is not consistent with our findings.

It's interesting to note how different the endoparasites are depending on the breed and species of animal:

In rational breeding, we marked the appearance of *Eimeria sp.* with a frequency of 12.50% and *Cryptosporidium sp* with a frequency of 0%, this is due to an obvious response of the infested does to the treatment administered by the veterinarian, so it seems that the treatment introduced in this farm is effective as a preventive medical measure, in addition to the health measures implemented.

There are no known species for fattening. Results from the old hutch provided by **AMRIOUI and KHELIF (2016)** are very different from those from the current study. Given that the hutch was recently reinstalled following VHD contamination, this might lead to the reinforcement of hygiene precautions.

In traditional breeding, the frequency of the species *Eimeria sp.* was 37.50%, the frequency of the species *Cryptosporidium sp.* was 2.5%, and the frequency of nematodes was 0.83%.

The traditional farms had a higher infection rate than the rational farms did. This is probably due to the fact that traditional farms experience more of the various factors that favor the contamination of rabbits and the proliferation of parasites than rational farms.

The current study revealed that female rabbits had higher infection rates than male rabbits did, and that the most infected rabbits were older than 9-month-olds. This was in accordance with the associated risk factors. Additionally, traditional farms had higher infection rates than rational farms. It is unclear how gender affects the variation in infection rates, particularly for *Eimeria spp.* The predominance of infection in females may be related to the physiological state, particularly gestation and parturition. Stressors and hormonal changes that occur during pregnancy, delivery, and lactation have been shown to reduce a person's resistance to parasite infection, according to **Xiao et al. (2004).** Infection spread is significantly aided by females, according to **Pappeshi et al. (2013).** It is likely that the lactation period is responsible for the low frequency of infection, particularly by coccidia, in young rabbits under 2 months old. In our research, it's possible that the contaminated environment makes rabbits more prone to infection after weaning. According to **Pappeshi et al. (2013)**, the period between days 46 and 51 after weaning is when infection intensity is at its peak. According to several studies, young rabbits are more prone to infection than adults, who are thought to be healthy carriers **(Pakandl, 2009; Coudert et al., 1995; Lebas et al., 1996; Bhat et al., 1996).** However,

Pakandl et al. (2007) suggested that contamination of young rabbits as young as 21 days of age may be significantly influenced by the increased nutritional needs during the lactation period.

Our research centered on the domestic rabbit Oryctolagus cuniculus, which is susceptible to coccidiosis. We discovered during the winter work period that females at various physiological stages (gestation, lactation) have high parasite excretion. The excretion of Eimeria oocysts is maximal in winter and autumn and almost nonexistent in summer and spring, according to similar observations made in Europe by **GRES et al. (2003).** In contrast, **GALLAZZI et al. (1977)** report a remarkable increase in oocystal excretion in pregnant and lactating females, which may be related to the negative energy balance that favors the decline in immunity during these times.

Oocyst excretion appears to peak in post-weaned rabbits during the first or second week after weaning. Both the change in diet (quality and quantity of the food distributed) and the great sensitivity of young animals in the presence of an immune system that is still developing could account for this.

The animals were chosen based on the cage design in order to study how it affected the development of coccidia, as well as the fact that the animals are housed in very small cages due to the small surface area of the facility. Considering all the information, it is clear that this way of life increases the likelihood that the animals will become contaminated. However, we cannot conclusively state that there is a connection between the placement of the cages and the appearance of parasites.

Our findings showed that the frequency of ectoparasites was zero in both types of reproduction, which was largely attributable to unfavorable climatic conditions. To put it another way, as previously mentioned, our study period was less than four months of winter, which is an unsuitable environment for the survival of external parasites.

Additionally, sampling and the use of parasiticides may have an impact on this results.

Conclusion

Conclusion

Many sub-Saharan African nations have a thriving livestock industry that includes raising rabbits. The number of people raising rabbits for food has increased recently, and breeders are showing an increasing amount of interest in the activity. The breeder doesn't have to put much effort into raising a rabbit. Today, a sizable segment of the populace adores and consumes rabbit meat. As the activity grows more intense, it encounters various ailments, including parasitic diseases, which reduces its profitability.

A significant overall infection rate of gastro-intestinal parasites was discovered as a result of this study, which was carried out in the Djelfa region for four months with the goal of estimating the prevalence of gastro-intestinal parasites and ectoparasites in 120 rabbits collected from various locations. The overall prevalence was influenced by various host-associated risk factors. The absence of ectoparasites infestation set the current study's findings apart. Three different parasite types were found to be present in rabbits, the most common of which was Eimeria spp., which causes significant financial losses in rabbit farms. Regarding the discovery of Cryptosporidium spp., the current investigation provided an intriguing epidemiological result. Our study offers preliminary data on the intestinal parasites that affect rabbits; further study will be necessary to fully comprehend the prevalence and true impact of the diseases caused by these parasites.

A better understanding of food can help prevent diseases that result in gastrointestinal issues that are conducive to the development of coccidia, which can help delay the disease's onset. Young rabbits after weaning are found to be susceptible to coccidiosis in addition to poor hygiene. Breeders must intervene with their treatment in order to stop the disease from spreading among broilers.

In the Djelfa region, rabbit breeding is growing in acceptance. For the meat industry, to boost output and revenue. When using this type of water gardening, the bunnies eventually react favorably. The need for a "healthy" diet free of drug residue was made more popular as a result of this. It follows that the growth of this industry cannot be stopped.

To ensure the success of this development, we suggest the following:

- ✓ Building and planning should take into account the environment in which the animal lives, especially during the warmer months when the rabbit seems to be more sensitive.
- ✓ Installing new feed production facilities to boost output and prices while also improving quality and quantity.
- ✓ Offering locally made, inexpensive livestock equipment (such as breeding cages, nipples or pipettes, nest boxes, etc.).
- ✓ Establishing official rabbit slaughterhouses to regulate food safety and better organize the marketing department.
- ✓ Training is provided to breeders who focus on raising rabbits.
- ✓ To identify common diseases, an epidemiological study is being conducted.
- ✓ To reduce mortality and protect consumers, the medical preventative program and health monitoring must be changed.
- ✓ Veterinary product availability and generalization of research findings.

Our research also advances our knowledge of the major parasite diseases affecting the gastrointestinal tract and external gastrointestinal tract in rabbits from the Djelfa region, which has not received much attention in Algeria. It would be best if others finished it.

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الملخص:

أجريت هذه الدراسة لتقدير مدى انتشار الطفيليات المعدية المعوية الرئيسية والطفيليات الخارجية التي تصيب الأرانب الداجنة التي تربى في نوعين من المزارع (التقليدية والعقلانية) في منطقة الجلفة. خلال فترة 4 أشهر، تم أخذ 120 عينة برازية من 10 مزارع في ست مناطق تقع في منطقة السهوب هذه. تم تحليل جميع العينات عن طريق الفحص المجهري باستخدام تقنيتين بما في ذلك التعويم والتعديل. أظهرت نتائجنا أن الإناث أكثر إصابة من الذكور، الأرانب الذين تتراوح أعمارهم بين 3 إلى 9 أشهر وأولئك الذين تزيد أعمارهم عن 9 أشهر لديهم أعلى معدلات الإصابة. تم تسجيل معدل إصابة 82.60 ٪ و50.50 ٪ في المزارع التقليدية والعقلانية، على التوالي. أظهرت الأرانب المصابة بالإسهال معدل إصابة مرتفع (87٪) مقارنة بالأرانب غير المصابة بالإسهال (49.5٪). من بين العينات التي تم فحصها، ايميريا قدم الطفيلي الأكثر اكتشافا (53.33٪) في الأرانب التي تم فحصها. كريبتوسبوريديوم تم الكشف عن انتشار (3.33٪). أصيب أرنب واحد فقط باليرقات الخيطية. لم تظهر جميع الأرانب التي تم فحصها أي إصابة بالطفيليات الخارجية. تشير هذه الدراسة إلى بيانات مهمة عن الطفيليات المعدية المعوية التي تصيب الأرانب الداجنة في منطقة الجلفة.

الكلمات المفتاحية: الجلفة، أرنب محلي،تعويم،التعديل، شروط التربية.

Abstract

The present study was conducted to estimate the prevalence of the main gastrointestinal parasites and ectoparasites infesting domestic rabbits reared in both traditional and rational farms from the Djelfa region. During a period of 4 months, 120 faecal samples were collected from 10 farms in six localities located in this steppic region. All samples were analyzed by microscopic examination using two techniques, including the flotation and modified Ziehl Neelsen staining. Our results showed that females are more infected than males. Rabbits aged 3 to 9 months and those older than 9 months had the highest infection rates. An infection rate of 82.60% and 50.50% were recorded in the traditional and rational farms, respectively. Rabbits with diarrhea showed a high infection rate (87%) compared to non-diarrheic rabbits (49.5%). Among the samples examined, *Eimeria* spp. presented the most detected parasite (53.33%) in the examined rabbits. *Cryptosporidium* spp. was detected with a prevalence of 3.33%. Only one rabbit was infected with nematode larvae. All examined rabbits showed no infection by ectoparasites. This study reports important data on gastrointestinal parasites infecting domestic rabbits from Djelfa region.

Key words: Djelfa, domestic rabbit,flotation, Ziehl-neelsen, rearing conditions.

Résumé

La présente étude a été menée pour l’estimation de la prévalence des principaux parasites gastro-intestinaux et ectoparasites infestant le lapin domestique élevé dans deux types d'élevages (traditionnel et rationnel) de la région de Djelfa. Durant une période de 4 mois, 120 échantillons de fèces ont été prélevés à partir de 10 fermes dans six localités situées dans cette région steppique. Tous les échantillons ont été analysés par un examen microscopique en utilisant deux techniques incluant la flottation et la coloration de Ziehl Neelsen modifiée. Nos résultats ont montré que les femelles sont plus infectées que les mâles. Les lapins âgés de 3 à 9 mois et ceux âgés de plus de 9 mois présentaient les taux d'infection les plus élevés. Un taux d'infection de 82,60% et 50,50% ont été enregistrés dans les élevages traditionnels et rationnels, respectivement. Les lapins diarrhéiques ont montré un taux d'infection élevé (87 %) par rapport aux lapins non diarrhéiques (49,5 %). Parmi les échantillons examinés, *Eimeria* spp. présentait le parasite le plus détecté (53,33 %) chez les lapins examinés.*Cryptosporidium* spp. a été détecté avec une prévalence de 3,33%. Un seul lapin a été infecté par des larves de nématodes. Tous les lapins examinés n'ont montré aucune infestation par les ectoparasites. La présente étude rapport des données importantes sur les parasites gastro-intestinaux infestant le lapin domestique dans la région de Djelfa.

Mots clés : Djelfa, lapin domestique, flottaison, Ziehl-neelsen, conditions d'élevage.