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2. Hydatidosis by *Echinococcus granulosus*: Update and description of the situation in Patagonia (Argentina)

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Abstract. Hydatidosis or cystic Echinococcosis is a zoonotic parasitic infection which is worldwide spread. It affects human beings, livestock and wild fauna. This parasitosis is caused by the larval stage of *Echinococcus granulosus*, cestode of an indirect biological cycle. This review focuses its attention on the situation of this disease in Patagonia (Argentina).

Introduction

Hydatidosis or echinococcosis, is nowadays a socioeconomic serious problem and has been considered one of the neglected zoonosis in those poorer towns of Latin America by the PAHO/WHO [1]. This disease can be found mainly in countries where there is stockbreeding activity. Depending on

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the eco epidemiologic scenario in which this disease evolves, it can be controled and even erradicated. The life cycle of the parasite has been known since 1853, some control actions -such as health education and slaughter control. Started in 1864, and the control of the presence of the parasite at the definitive host – canine – started in 1890. These sort of actions were enough to erradicate echinococcosis in insular places, such as Iceland, Tasmania and New Zealand. Continental places haven't achieved this success yet [2].

At present, there are new options for the diagnosis and treatment of the disease in human beings, as well as for the prevention, control and monitoring. Regarding the last decades, it is important to emphazise the development of vaccine EG95 which can be administered in animals that act as intermediary hosts, and the test of coproantigen for diagnosis in definitive hosts and for monitoring environmental pollution with the parasite.

Life cycle and transmission of *Echinococcus granulosus*

Echinococcus granulosus is a diheteroxenic parasite. That is the reason why it needs two hosts to finish its life cycle; a meat-eater definitive host, such as the dog – *domestic cycle* -, or the fox – *wild cycle or synanthropic cycle* - in whose small intestines it is developed the adult strobilar stage, and an intermediary hoofed host, for example sheep, goats, cattle, horses, domestic camelidos from South America and pigs, in which hydatid usually develops in internal organs like the liver and the lung. In wild cycle or synanthropic cycle intermediary hosts such as rodents and wild South-American camelidos may have an important role [3]. The human being is considered an accidental paratenic host, who is infected when he ingests the parasite eggs and may develop the pathology.

As regards risk factors related to domestic cycle of hydatidosis the following have been highlighted in the Patagonia (Argentina) [4]; domiciliary sheep slaughter (OR: 3,2), dogs possession (OR: 2,6; $p<0,05$), family history (OR: 2,5) and average number of years living in rural areas ($p<0,05$), the availability of drinking water being a protection factor (OR: 0,1).

On natural conditions the transmission of *E. granulosus* is the result of the relationship between the prey and the beast of prey existing between hosts, the environment being the surrounding where part of the life cycle of these parasites takes place. The parasistic population is determined by three sub populations in one moment [5]: adults at the definitive host (*DH*), larvae (metacestodes) at the intermediary host (*IH*) and eggs in the environment. Thus, the first link in the transmission chain of said pathology is the intake by

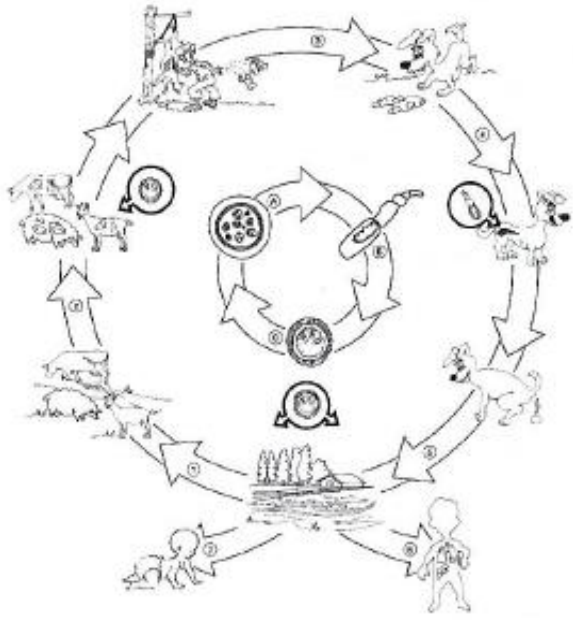

Figure 1. Domestic cycle of *Echinococcus granulosus* in Patagonia Argentina. **A.**- Larvae in intermediary hosts. Protoescolices in hydatid cysts of sheep, goats and other herbivore animals. **B.**- Adults in the definitive host. Echinococcus granulosus in the intestine of dogs. **C.**- Eggs in the environment contaminate water, soil, grass and vegetables.
1.- Intermediary hosts ingest the eggs of *E. granulosus* parasite, which contaminate grass and water. **2.**- Hydatid cysts are developed in lungs, liver and other viscera which may have protoescolices inside (fertile cysts). **3.**- During sheep and goat slaughter, for consumption or trading, the dogs may have access to viscera, especially the liver and lungs. **4.**- A dog that eats viscera parasitized with fertile hydatid cysts develops the adult *E. granulosus* parasite in its intestine. **5.**- *E. granulosus* eggs are periodically eliminated with the feces of the parasitized dogs producing biological contamination of the environment. **6.**- The man can get infected by being licked or touched by a dog parasitized with *E. granulosus* and by ingesting *E. granulosus* eggs when eating vegetables or drinking water contaminated with feces of a parasitized dog. **7.**- Children are the most likely to get infected.

IH of eggs eliminated with feces by *DH* that contaminate the environment. The factors that contribute to the dynamic of transmission of the Taeniidae parasites, in which *E. granulosus* is found, are classified in extrinsic factors (temperature environmental humidity, agents of eggs dispersion in the

environment, eggs aging); socio-environmental factors (stock farming activity, legislation) and intrinsic factors (biotic potential, innate immunity and acquired immunity). The effect of temperature upon the subsistence of eggs has been described in samples controlled at the laboratory [3]. In these cases, it was reported that tolerance limits to temperature of *E. granulosus* eggs are between +40°C and –70°C, and that the exposure to 0% of relative humidity during 24 hs is lethal for them. The research carried out up to the moment in relation to the viability of eggs *E. granulosus* under natural conditions of the environment, has shown that such eggs are able to survive in snow and under freezing conditions, keeping viable at least for one year in pastures of New Zealand and that are sensitive to direct solar light exposure and to temperaturas of 51°C on the ground, in Turkana (Kenia) [6]. In the Province of Chubut (Argentina) it was proved that under natural conditions of arid climate, the presence and dispersion of *E. granulosus* eggs were related to the following factors of the ecosystem: defecation habits of infected dogs, infection load of each dog, prevalent direction of winds, topography and superficial water [5]. Under said conditions it could be determined that eggs kept viable during 41 months, being in the stages of mature egg and semi-senescent egg, and that embryos included in those eggs were able to penetrate, stay and start the development post oncosfera towards the larval stage of the parasite, preserving during the before mentioned period of time its capability of producing cyst in the sheep intermediary host [6].

Epidemiology

Hydatidosis has been reported in every Continent except for Antartica. Its incidence is very important in some countries of Europe, Asia, Africa, Oceania and South America [3].

In the continent of Europe the most important occurrences of hydatidosis take place in the mediterranean, south-east and east regions [7]. An annual rate of 4-8/ 100,000 inhabitants hydatidosis events in human beings have been reported in zones of Spain, south of Italy, Sardinia and Bulgaria. Great Britain is another country affected for this disease in cattle in zones where they are raised.

In Central Asia hydatidosis has been considered a re-surging pathology having serious problems of sub-notification since the decade of 1990 [8]. In countries such as Uzbekistan, Kazakhstan, Kyrgystan and Tadjikistan the disease in human beings has reached an annual rate over 25/100,000 inhabitants. In the rest of Asia, China is one of the most affected countries [3]. In the endemic province of Xinxiang the average annual incidence of surgical events was of 8.7 events/100,000 inhabitants, and some regions

reported values of 42 events/100,000 inhabitants. The most affected age groups were between the ages of 6-15 years old.

In Africa, the countries of the north are endemic for hydatidosis [3]. In Morocco, the average annual incidence of events in human beings for the period of time between 1980-1992 was of 4.8 events/100.000 inhabitants, some regions presented values of 15.8 events/100.000 inhabitants

In Oceania, hydatidosis is still taking place in Australia. The average annual incidence of events in human beings for the period of time between 1991-1994 was of 0.23 events/100.000 inhabitants [3].

In South-America hydatidosis has an effect on most of the countries, having an important impact on public health in Argentina, Chile, Uruguay, Perú and south of Brazil [9]. In these countries, the tranmission of *E. granulosus* is endemic in those regions where the environmental conditions are appropriate for raising sheep and other domestic hoofed animals.

In Uruguay, according to some records based on surgical cases in the year 2000, the incidence of the disease in human beings was of 6.25/100,000 inhabitants, and in Argentina the annual prevalence was of 1.4 cases/100,000 during the decade of the year 2000 [9].

In Argentina cases of human hydatidosis have been reported in all the provinces. Between the years 1994 and 2007, 6228 occurrences were reported to the Ministry of Health, which is equivalent to an average of 445 occurrences per year, with a relation man/woman of 0.88. The higher rates of the year 2007 were reported in the provinces of Neuquén and Santa Cruz with 10.76 and 7.11 occurrences/100,000 inhabitants. However, in regions defined as endemic, some serologic and ultrasonogram surveys hold in asymptomatic populations, for example school boys and girls, showed prevalences in upper hydatid cysts carrier [10].

The socioeconomic impact that hydatidosis causes is due to the infection in human beings and livestock and to the costs that the implementation and support of a control programme gives rise to. In Uruguay, for example, the costs taking into account hydatidosis in human beings and livestock have been calculated between 2.9 and 22.1 million U$D [9].

As for infection in human beings, economic losses are related to medical costs of diagnosis and treatments, work absenteeism, abandonment of farming and cattle raising activities, and social consequences associated with disability and death rate. In the province of Río Negro (Argentina), in the year 1997 the average cost per infected person was of about 4,500 U$D [4].

As regards livestock, economic consequences related to hydatidosis include the reduction in yield and quality of wool, meat and milk, the decrease in development and growth of infected animals, and losses due to the confiscation of organs (mainly liver and lungs). Some trials to test the

effectiveness of the vaccine EG95 carried out in the province of Chubut (Argentina) between the years 1996 and 1999, stated that 15 sheep without hydatidosis produced 8.6% more meat than 5 sheep with a period of 22 months of the disease. Wool production, measured at the moment of shearing, gave a result of 9.1% higher in healthy sheep than in infected ones, after 12 months of sickness [11].

The hydatidosis in the Patagonian region of Argentina

Statement of condition and legal aspects

The region of Patagonia (Argentina) is composed of the provinces of Tierra del Fuego, Santa Cruz, Chubut, Río Negro and Neuquén. It has a surface of 787,054 km^2 and there are 1,838,000 inhabitants.

According to Guarnera [2009], and the National Census of the year 2001, it is estimated that 194,266 people would be in risk of suffering hydatidosis and 20,290 of them are under the age of five years old. These people live at risk areas because they are rural settlers, living as crowded rural population or as scattered population. Even though every person sharing the parasite habitat may get ill, the appropriate conditions are given for those who live in areas of cold weather and within the age group of five years old. The infection in children can be explained because oncosferas, which are the infecting unit, are scattered on the soil nearby the houses; that is the place where kids start their relationship with the environment, crawling, walking and playing, and that's why the normal development of their lives put them in contact with the oncosfera at early times [12].

Several species of grass-eating and omnivorous animals can be intermediary hosts (IH) of hydatidosis in this region (Figure 1). Among the grass-eating domestic animals that can be IH hosts in Patagonia (Argentina), the following can be found: goats, sheep, pigs, horses; and among wild animals, guanacoes and hares.

Among canines, the domestic dog is the main definitive host (*DH*) and red and grey foxes may be part of the wild cycle. Hydatidosis is considered the most important zoonosis in Patagonia Argentina. There are about 14.000.000 of *HI* apt to catch hydatidosis and 150.000 *DH* apt to catch echinococcosis. *E. granulosus* is the only species of the parasite found in this region. There are at least 3 strains of the parasite in the region: common sheep (G1), Pig (G7) and Camel (G6). The sheep strain is the one with the greatest epidemiologic importance in the zone.

The National Law for prevention of Hydatidosis, the Federal Law of Sanitary Meat, the technical standard and procedures manual for control of

hydatidosis in Argentina [10], provincial laws which all provinces have and several city ordinances, give a legal and technical framework to that actions of control programes. The putting into practice of these programmes caused an important decrease of prevalence rates and the risks for people of falling ill, even so, people born after starting the programmes are still falling ill [9].

In the province of Neuquén (Argentina) the prevalence of canine echinococcosis was of about 28% in the year 1.972 and since the year 1.999 this prevalence keeps in values of about 1%. Regarding ocurrences in human beings, the annual average incidente (*IMA*) for the period between the years 1995-2004 was of 24.4% /100.000 inhabitants. The *IMA* for the age group between 0-14 years old is of 9.7 events/100.000 inhabitants for the same period of time [13].

In the province of Río Negro (Argentina) the prevalence of canine equinococosis evaluated by arecoline purgation reached the 41.5% in 1980, 2.3% in 1997 and 5.2% in 2003. This dramatic decrease of the prevalence is subsequent to the aplication of praziquantel tenicide. The sheep hydatidosis had a prevalence of 61% in the year 1980 and 10.2 in the year 2001. As regards hydatidosis affecting human beings, the Provincial Registry identified 1833 new ocurrences in the whole province in the period 1980/1998. Between the years 1999/2002 were registered 57 new ocurrences per year and in 2003 44 new ocurrences were reported [14].

In the province of Chubut (Argentina) in 1984, the prevalence of canine equinococosis in rural zones reached 70% while in urban zones reached a rate from 0% to 48%. The sheep hydatic prevalence according to information taken from official abattoirs were over 25%, reaching the 60% in the mountain-range region. The rate of annual surgical cases was of 84/100,000 inhabitants. In the year 2008 the prevalence of canine equinococosis was in most departments under 3%, and in some zones a prevalence of 6%. The sheep hydatic prevalence was between 0% and 10%, and the rate of surgical ocurrences in human beings by espontaneous request and active searching for asyntomatic carriers, was of 10 cases/100.000 inhabitants. [Jensen O., personal communication].

In the province of Tierra del Fuego (Argentina) the actions for controlling the faena in farms started in 1976, with an infection rate in sheep of 55% and in the year 2001 was of 2.5%. In 1979 the prevalence of canine was of 80% and in 2001 of 1,8%. Between the years 1988/1996 25 new records of human hydatidosis were reported. During the years 1997/2006 657 children and 743 adults, were examined by ultrasound scanner, all of them were people from rural zones, giving as a result a prevalence of 1,0% in kids and 1,7% in adults [15].

Domestic cycle and wild cycle

The cycle dog-sheep is present in all the territory. Sheep are considered the most important *HI* because of its distribution, its sheepherding habits, the way of collecting the forage, the periodicity of parasitization, their cyst fertility, the frequency with which they are slaughtered for domestic consumption and the need of having dogs to handle the sheep [Fig. 2]. The only exception to this situation is Neuquen province, were goats are the most important intermediary host [13]. At the beginning of the 21st century about 8,500,000 sheep grazed in about 7,500 settlements where there were 35,000 dogs.

At those regions where goats replace sheep and are part of a subsistence economy, the cycle dog-goat is found. Open field grazing, overnight enclosure, and the pastoral system of transhumance are typical features.

The bovine breeding is increasing in Patagonia Argentina. However, because of low fertility of their cysts and poor slaughter of adult animals, its epidemiologic role is not important. For this reason they are considered bad hosts taking into account the continuity of the parasite cycle.

Wild animals very likely to be part of the hydatidosis cycle live at the same environment of domestic animals. Red and grey foxes (*Dusicyon culpaeus, D. grisaseus*), carnivorous animals, eat domestic and wild *HIs,* which is why they can ingest *E. granulosus's* protoescolices. The red fox is hunter, meanwhile the grey fox when eats *HI* they are dead animals or killed by other meat-eater animals. That is why grey foxes would have more chances to get the liver and lungs of *HIs* and so get contaminated with *E. granulosus.* Hares (*Lepus europaeus*) guanacoes (*Lama guanicoe*) are likely to get infected when they get food in an environment contaminated with eggs from the parasite.

Some tests performed in the city of Trevelín (Province of Chubut, Argentina), between the years 1984/85, on 10809 hares, 5 of them showed hydatid cysts [Gonzalo, R., 1986 personal communication]; and tests performed in the south of the province of Chubut (Argentina) in the period 1984/87 hydatid cysts were not found in 300 viscera coming from hares, guanacoes, skunks red deers. *E. granulosus* were not found in 120 small intestines from grey and red foxes tested. Fifteen grey foxes were artficially infected with protoescolices which were gotten from ovine cyst, and after arecoline test and after performing the autopsy, adult *E.granulosus* were not found. The existence of the illness in wild animals may assume a lesser risk in human beings, since foxes live away from populated places, farms and small towns in Patagonia. It should be taken into account the risk of the exposure of the country man when skinning a fox to get its skin, because of

his possible touch of the rest of feces which remain on the anal area of the animal [11].

Eco epidemiology of hydatidosis in hosts and in the environment: present knowledge and new prospects

Patagonian environment with its large extension and diversity of phytogeographical regions, has regions with mild or cold temperatures, regular and reduced humidity, sun radiation, good grass covering, fresh water, and with appropriate *DH* and *IH* to let hydatidosis/echinoccocosis develop (Figure 2). *E. granulosus* eggs are done away with feces from *DH* causing the biological pollution of environment and as it was mentioned before in patagonian plateau said eggs remain for 41 months (5,6). Different grazing habits, the way of getting forage and the water that grass-eaters *IH* hosts drink, feeding and defecation habits of meat-eaters *DH*, the health/ zootechnician management of hosts and bioecology of eggs of teaenias, are factors that play an important role in persistence and transmission of the disease in this region.

In Patagonia (Argentina), domestic slaughter, in farms and small fields is a frequent and necessary activity in order to obtain the main food for rural people. We can find a suitable slaughterhouse with a septic tank, or producers who perform open-cast slaughters where there are no possible controls. Depending on necessity and customs of each person the animal they choose for slaughtering varies. Some people slaughter old animals that are in production declension so as to preserve its capital or because these animal are not likely to survive the following patagonian winter, and some others slaughter lambs or young capons. The exposure time to infection risk is different in virtue of animal age. The dog can be considered a specialized working tool, an employee to feed, one more member of the family, a faithful friend or one digestive/ trash collector. Based on these concepts it will be given cares and food. There aren't many choices for dog foods in Patagonia. Apart from this, dogs receive different viscera during the slaughtering. Some people give the liver of the dead animal to the dog which is considered the best one or to the home dog. Some other keep the set of liver and lung for a second meal that is only destined to those dogs that the owner most appreciate. In a general point of view, *E. granulosus* are found protected in the intestine of the *DH* host. During domestic cycle, the man is who usually favors the accidental or non intentional ingestion of eggs to livestock or to themselves. The man is who makes decisions that are related to hydatidosis risky behaviors. The protoescolices are found protected in hydatid cysts located in organs of *IH* hosts. In domestic cycle, the man often gives

parasitized viscera to the dogs after slaughtering animals for own consumption or for selling; and so the man becomes the first responsible for the spreading of hydatidosis; because of ignorance; custom, necessity or irresponsibility. The man is who decides to have dogs, who chooses the food for dogs, who performs deworming or not and chooses where to place the kennels. The man also decides on the places and times for grazing of livestock. Moreover, the stealing or getaway of viscera from enabled places for slaughtering; the parasitized viscera that arrive at public stores for selling them; the viscera that are food for dogs which are in abattoirs or the employees working at them; the viscera that are used for feeding pigs and where dogs eat the same viscera along with them; these are all facts that contribute to this zoonosis to get from the farms to the city, keeping the cycle of the disease in urban zones.

To this effect, it is understood that Health Education is an essential point of the Control programs in Patagonia (Argentina) and that giving specific information about the ways transmission, prevention and control, may have a direct influence on the decision chain before mentioned.

Monitoring and control of hydatidosis in Patagonia

In the year 1948 the Ministry of Agriculture started the first attempt for controlling hydatidosis with static clinics, constituted by volunteer workers and movable equipment which cover part of the provinces of Río Negro, Chubut, Santa Cruz and Tierra de Fuego in the crusade called "*Campaña de Saneamiento Integral de la Patagonia*". The strategy was the concentration of dogs, dosage with the hydrobromide teniafuge of arecoline and health training giving talks at schools and showing at cinemas.

In the year 1970 the province of Neuquén and in the year 1975 in the national territory Tierra del Fuego some control program are started having as includible requirement the need of steadiness to achieve success in control and periodic dosage with praziquantel tenicide.

In the decade of 80's the provinces of Santa Cruz, Chubut and Río Negro started their programs, disrupting the disease cycle by means of monitoring and periodic de-worming of domestic definitive host in those places where slaughtering takes place, and health education of the population which is exposed to the risk of falling ill. At this point it is necessary to articulate control actions with activities assigned to health prevention, and adding the society as active participant of the programmes and replacing the dominant figure of "Chief of the program" to the "interdisciplinary task force" that give support to the tasks of auxiliary nurses and rural hospitals.

In the decade of 90's the patagonian programmes were more consolidated with an important activity of the man, based on searching operations of asymptomatic carriers and surveys of epidemiologic situation of the disease through serology and screenning ultrasound scan, in risk groups as inhabitants of endemic areas, to live in rural cattle areas, families which have parasitized dogs carrying canine taenias, families with "hydatid records" and ordinary population, giving priority to kids under the age of 15 years old.

The fact of detecting asymtomatic hydatid cyst carrier people, allowed to shorten the natural history of the disease and to establish the pharmacologic treatment. Besides, the control of canine population, the monitoring of orchards and monitoring of wild animals were are added [16].

It is possible that new tools such as monitoring canine echinococcosis with coproantigen test, serologic monitoring in the intermediary host, systems of geographical information, monitoring of echinococcosis in the environment, biological control and vaccine control, are added to the control programs in the following years.

Periodic de-worming of dogs

On the first crusades the hydrobromide teniafuge of arecoline was used for diagnosis and treatment. Since 1975 the tenicide nor ovicidal, praziquantel, is used as treatment and that purveys in a planned and methodic way in a dose of 5 mg/kg; it allows the decrease in a quick way of parasitized dogs with *E. granulosus* and decrease of parasitic biomass in the environment. It is purveyed in pills with a periodicity of 45, 90, 180 or 360 days according to the prevalence of each region and strategy of each program. The most favorable diagram consist of carrying out canine de-worming every 45 days, at least during the years that the natural changes of the sheepfold and environment decontamination take place. The aim is to eliminate in each opportunity, the new taenias before they start to produce eggs, since the drug is not ovicidal. According as the scope of systematic de-worming come towards the complete population of dogs in a certain area, the risk of infection for the human being and livestock goes down gradually and progressively until the transmission is completely blocked [17]. The programs have the problem that they don't count on the drug in due course and that the drug reaches the stomach of each dog in an appropriate dose. The de-worming diagrams have as main limitation the problem of achieving an effective scope over 80% of existing dogs, in each of the rounds of planned de-worming, because of economic difficulties, geographical, climatic or by socio-cultural contributing factor in areas under treatment.

Control in slaughter sites

In the places enabled for slaughter located at common land of each city that have bromatology inspection, it must be forbidden the outgoing of parasitized viscera with hydatid cysts, specially livers and lungs. The corresponding agency -municipal, provincial or national- has to establish and keep procedures for controlling the disposal of viscera at meat processing plants and abattoirs [18].

Monitoring the infection sources is central for the control programs of the region, so as to cut life cycle of the parasite. The control program, must carry out an effective supervision of the sanitary inspection; of the destruction or denaturalization of confiscated viscera; of the compliance with measures to prevent dogs from entering to the place; of the compliance with standards that control the way out of viscera from places of slaughtering; of the construction of appropriate places for slaughter in each of the cities; and adding the veterinarian inspection.

Health education for people

Health education and health promotion to the people exposed to the risk of contracting hydatidosis is an important tool but slow, that will give rise important outcomes in a long-term. The objective is to make people change their habits and behavior so as to control and to eradicate the disease.

The central point of these educative activities is focusing on the risks that feeding dogs with cattle viscera, the direct contact with dogs and the benefits of an apt alimentary hygiene and periodic dog de-worming. These activities are reinforced (or enforced) with educational material (such as, booklets, audio-visual aids, posters, etc.) which share-out makes people to be interested on all these topics [10].

The primary health care auxiliary nurses, teachers working at schools in endemic regions and people involvement are essential factors. As enforced for the educational actions, the "Semana de la hidatidosis" (hydatidosis week) is carried out once a year. During this week some educational intensive techniques are taught so as to promote health, prevent disease and monitor actions. Besides the health sector, the educational sector and mass media take part as well.

Control of canines

Canine control at urban zones is the responsibility of local authorities and it is extremely important to control hydatidosis. Therefore, a comprehensive

program based on responsible tenure of dogs, giving priority to public health and integrity of people. This program should include teaching strategies to the owners of the dogs and to society, a recognition system that transfres legal responsibility to owners, birth control, dog leash control, an adoption system and correct management of urban trash [18].

Control of orchards

Those family or marketable orchards, must be enclosured so as to prevent dogs to enter. It is necessary to make a written report of the presence of dogs and canine feces, putting aside every kind of vegetables which may have been in touch with them [18].

Surveillance of wild animals

The infection in wild animals is an obstacle in order to eradicate hydatidosis, since most of the strategies put into effect didn't reach the wild cycle. Searching for HC in hares which are at enables slaughterhouse, searching for *E. granulosus* eggs in foxes rawhide and searching for endoparasite in foxes are carried out nowadays.

Surveillance in definitive hosts

It is so very important to determine the prevalence of echinococcosis in the *HD* for the control and surveillance of the disease. Epidemiologic control in dogs allows to identify real levels of transmission in a certain geographical area and likewise, it allows to quickly evaluate and in a short-term if the actions taken are achieving to effectively shorten the echinococcosis cycle [10].

The oldest technique used is making use of a tenifuge, arecoline hydrobromide, by oral administration at a dose of 4 mg/kg, with macroscopic diagnose in situ. This method allows to recognize the infected dog, the *E. granulosus* parasite and has a high educational impact. Some other taenias are eliminated such as *Taenia hydatigena* and *T. ovis*, being its diagnosis of epidemiologic interest even as it allows to identify dogs that eat raw viscera or taenias that also affects the human being such as *Diphyllobothrium latum* and *Diphylidium caninum*, or taenias like *T. pisiformis, T. serialis, T. taeniaeformis* which indicate feeding with other intermediary hosts. Every taenias show that they were not correctly de-woming. It also exists other intestinal parasites that can affect to the human being, for example those of the *Toxocara* spp.

The coproantigen techniques, like Copro Elisa/Copro Western blot or copro-PCR are enable to test at labs feces samples sampled by rectal swab or by collecting feces from the place the dog is laced.

Surveillance of intermediary hosts

Epidemiologic surveillance to cattle allows to quantify parasitic load into the intermediary host which is useful to estimate the transmission dynamics at a specific geographical area. The prevalence in young animals, point out the level of nowadays or recent past transmission [10].

The prevalence studies of hydatidosis in livestock, per age group and origin, enable us to measure directly or indirectly the level of environmental contamination, changes at infection levels, to calculate economic losses, to locate farms with infections or free of them, to find parasitized dogs, to estimate tendencies, to enact actions based on risks and to evaluate the impact of the programs. The rate of confiscation because of hydatidosis reported by enabled abattoirs also gives information of a less epidemiologic value.

Figure 2. Typical image of a Patagonic rural area in Argentina, where sheep breeding is usual. The different components of the *E. granulosus* domestic cycle are shown here: dog –definitive host-, sheep –intermediary host-, human being -accidental host-, and environment (Photo: Paula Sanchez Thevenet).

The method traditionally used for the anatomo pathological diagnosis in livestock is the post mortem determination of hydatid cysts (HC) at slaughter places. It is a low cost strategy which is also easy to carry out. Visual inspection, palpation and incision of the organs are used. Apart from its epidemiologic value, this technique allows obtaining hydatidic liquid and protoescolices, which are necessary for serologic diagnosis, fertility viability and strains studies.

It is useful to count on a method that allows the identification of HC carrier animals. Serology and ultrasonography are new tools to be consider. Due to its low cost and minimum equipment requirement, serology is the generally chosen one. Mass diagnosis has the same uses as the diagnosis carried out during slaughter, but the fact that it is performed on the alive animal grazing at the stockbreeder farm is an advantage. Individual diagnosis allows the cattle raisers to select the animals for domestic slaughter and to carry out an anticipated sale of ruminants with hydatidosis. Control programs will be able to regulate the sale of animals with hydatidosis only to enabled slaughter sites or to implement the purchase of parasitized animals by the State.

Treatment of intermediary hosts

So far there is no chemotherapy treatment, similar to the treatments used in humans, that enables a practical treatment of the hydatid cysts in cattle. It is possible to use the antiparasitic drugs which are successful in humans. However, the cost of the antiparasitic treatment and daily dosing are drawbacks. The use of benzimidazole, such as albendazole, mebandazol and oxfebendazol, administered in intraruminal bolus or capsules of slow and sustained release of the antiparasitic drug during several weeks by means of osmotic pumps or simple abrasion, is being experimented in ruminants.

Geographic Information Systems (GIS)

Due to the complexity of the ecological systems of the hydatidic disease, it is necessary to use new tools of epidemiological surveillance that take into consideration the relationship between hydatidosis and the environment. Epidemiological surveillance of cystic echinococcosis, based on environmental observation units such as contaminated areas, risk areas, stockbreeder farms and sheep and goat owners, would be widely benefited in its capacity for epidemiological analysis by means of Geographical Information Systems (GIS) which include the information available [10].

Surveillance of cystic echinococcosis in the environment

The knowledge of the situation of the hydatidosis cycle in the environment is determined by showing the environmental contamination by *E. granulosus*. It can be determined by the diagnosis of the parasite or its constituents or metabolic products in recent or old dog feces collected from the environment. The diagnosis can be performed by means of immunological methods, applying the Immunoenzimatic-coproantigen Assay (ELISA copro-antigen), or molecular methods by means of the PCR technique [10].

The positive diagnosis of feces collected in a certain environment, shows that at that place there are and/ or there were in the last 5 years parasitized dogs with *E. granulosus* and so the environment is contaminated [5].

The negative diagnosis means that in the examined samples there were no antigens of *E. granulosus*. Maybe there is no parasite or maybe only negative sample were taken at random [10].

The incorporation of immunobiological methods that allow testing fresh feces, dry feces or soil and to measure environmental pollution, would optimize the diagnosis and surveillance. The connection with data about infection in the IH will bring a better information quality, allowing the determination of infected fields or areas, which would allow to plan the actions at those places with a higher risk and current transmission.

Biological control

It is necessary to have a practical and effective way to purify environments where people are present all the time, such as green spaces at homes and those of public use, for example public squares. The possibility of using disinfectant and/or saprophyte fungus, which affect eclosion, viability and eggs infectivity of *E. granulosus* should be added to the responsible tenancy and manual cleaning of dog feces.

Control with vaccines

There are several measures to prevent infectious diseases, vaccination is the most useful one. Vaccines are an effective and profitable mean to prevent and control, or even to eradicate, infectious diseases. If they prevent zoonotic infections, veterinary vaccines can protect not only animal health but also the health of human beings.

Control with vaccines in definitive hosts

A vaccine that reduces the production of *E. granulosus* eggs in the definitive host, could be potentially enough to limit the transmission at areas where the parasite is endemic. There is scientific research tending to develop a recombinant vaccine against *E. granulosus* to be applied in dogs that produces local and systemic immunity [19].

Control with vaccines in intermediary hosts

The incorporation of actions on the sheep line, preventing infection and diminishing the hydatid cyst offer, opens new perspectives to control programs because it makes it possible to attack the hydatid disease cycle from a different front, which will allow to achieve a sustained control of the disease along time [20].

The vaccine in the hydatidosis control programme is a practical tool which allows the prevention of the disease in the intermediary hosts by generating high antibody titers. This contributes to the closing of the disease cycle by reducing the offer of (HC) in the definitive hosts [21].

The Molecular Parasitology Laboratory of the University of Melbourne in Australia, the New Zealand Centre for Human-Animal Studies, the National University of Patagonia San Juan Bosco and the Department of Health of the province of Chubut in Argentina have developed and are currently assessing the experimental vaccine called EG95 in order to protect sheep and other intermediary hosts such as goats, cattle, pigs and camelidos from South America.

The vaccine called EG95 is a recombinant protein cloned from the RNAm obtained from the oncosfera of the parasite which, expressed as a fusion protein and applied together with the adjuvant Quil A, protects against infection by *E. granulosus* by inducing specific antibodies against the oncosfera of the parasite. The parasite is eliminated when infection occurs, before being able to settle down in the host's tissues. It is a purified protein preparation, noninfectious, non-toxic, non-contaminant [22].

The potential results of the recombinant vaccine in field trials carried out in Australia, Argentina, China and New Zealand were conclusive since they gave percentages of protection against challenge between 83 and 99% with one and two doses and 100% with a third dose. The protection scope reached a period of a year. For all minor ruminants, two doses must be applied at the beginning of the vaccination scheme to all animals. The first dose prior to lambing labour and the second dose at shearing time. In high risk areas an annual booster shot is necessary in all ruminants prior to calving labour, so as to generate high levels of calostral antibodies. Goats and lambs will receive

the first dose at the marking time. During the shearing work of adults, the second dose is applied to the lambs and goats and the scheme is completed in the rest of minor ruminants [23].

The vaccine is on the registration stage to the sanitation authorities of Argentina –the National Service of Animal Sanitation-, under the trade name of Hidatil EG95. The recombinant vaccine will appear in multi-dose vials, each of which allows to vaccinate 100 animals (each dose is 1 ml). It will be possible to formulate this vaccine together with others, bacterial or viral, in order to increase its intensity of use, out of official vaccination campaigns.

The vaccine EG95 has been tested since 2007, within the frame of a hydatidosis control program, in a Tehuelche aboriginal settlement located at the south west of the province of Chubut in Argentina. They herd a total of 30,000 hectares with 10,000 sheep and 1,000 goats. During 2009, the vaccine was tested in a stockbreeder farm dedicated to sheep breeding, located in Península Valdez in the province of Chubut in Argentina. This test compared the immunity given by the experimental vaccine EG95 and the vaccine to be produced in Argentina. It has been stated that, up to the moment, the vaccine Hidatil EG95 induces the production of a greater quantity of antibodies in the vaccinated sheep than the experimental vaccine EG95 [Jensen O., personal communication].

The availability of a recombinant vaccine against hydatidosis in minor ruminants will enable the reduction of the (HC) offer available for the definitive hosts, which implies the reduction of parasite biomass available for intermediary hosts. This veterinary vaccine has the special feature of protecting the health not only of the animals but also of the human being as it diminishes the risk of infecting people.

Hydatidosis control at stockbreeding sites

Stockbreeding sites in Patagonia must have an adequate place to slaughter animals for consumption. A simple place, with basic facilities, enough water, without dogs and with a sanitary well for the disposal of parasitic viscera are the minimum requirements.

A positive practice to bear in mind to destabilize the domestic cycle is to avoid feeding dogs with raw viscera from slaughtered animals [24] or to turn them, the liver and the lungs in particular, into safe food for dogs by chopping, salting, brining and especially boiling.

At stockbreeding sites, only the dogs necessary for the work with animals should be kept and they should be placed at the kennel sector when they are not working. The kennels must be far away from pens, parks, orchards and houses. The orchards must be closed by fences to prevent dogs from entering.

The cattle raisers from the Argentinean Patagonia can control and/or erradicate hydatidosis from their farm, without depending on the actions of control programs, by periodically deparasiting all their dogs with a tenicide drug and/or preventing their dogs from eating raw viscera and/or vaccinating their herd [25].

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