



# Abortive diseases and their various associated risk factors in small ruminants in Algeria: a systematic review

Asma Haif<sup>1</sup> · Nadjat Amina Khelifi-Ouchene<sup>2,3</sup> · Manal Khelifi<sup>4</sup> · Imane Ouchetati<sup>5</sup> · Fayçal Zeroual<sup>1</sup> · Nassim Ouchene<sup>2,3</sup>

Received: 15 January 2021 / Accepted: 10 September 2021  
© The Author(s), under exclusive licence to Springer Nature B.V. 2021

## Abstract

Abortive infections are a major health challenge affecting productive and reproductive performance of sheep and goats. However, there is no comprehensive summary on the occurrence and distribution of these infections in Algeria. This systematic review provides a comprehensive summary on the prevalence of different abortive diseases and assesses potential risk factors in small ruminants in Algeria. Five databases were used to search epidemiological data on the prevalence of different abortive diseases (bacterial, parasitic, and viral). Data were collected from 25 papers published between 2003 and 2020. The total mean sample size was 53,080 small ruminants. The majority of the diseases/infections were diagnosed by serological and molecular tests. The overall prevalence of brucellosis was 0.39% in sheep and 5.31% in goats. Chlamydia and Q fever were observed in 32.72% and 20.62% of small ruminants, respectively. The prevalence of peste des petits ruminants was 15.76% and the overall prevalence of bluetongue in sheep and goats was, respectively, 13.41% and 44.50%. Border disease and bovine viral diarrhoea were detected in 22.68% and 1.01% of sheep examined, respectively. *Toxoplasma gondii* infection prevalence among sheep and goats was 21.43% and 32.31% respectively. This study is a comprehensive epidemiological analysis of abortion diseases in small ruminants in Algeria and will therefore be a useful tool for researchers. Larger and more robust prevalence studies are needed to adequately support risk assessment and management of animal and public health threats.

**Keywords** Algeria · Abortive diseases · Goats · Sheep · Prevalence · Systematic review

## Introduction

Abortion in small ruminants is one of the major problems that can cause considerable economic losses due to the death of fetuses and reduced milk production and it may occur sporadically or as enzootic outbreaks. The etiology may be infectious or non-infectious (Vidić et al. 2007; Entrican

et al. 2009). Infectious abortions are the most common and are caused by bacteria (*Chlamydia abortus*, *Campylobacter* spp., *Listeria* spp., *Coxiella burnetii*, *Brucella melitensis*), virus (bluetongue virus; plague of small ruminants virus, border disease virus), and parasites (*Toxoplasma gondii*) (Celli and Gorvel 2004; Khan et al. 2011; Kaufmann et al. 2012; Martin et al. 2015; Tegegne et al. 2016; Elhaig et al. 2018; Tejedor-Junco et al. 2019). Abortions are also caused by non-infectious etiologies such as toxicities, genetic factors, metabolic and nutritional problems, and physical factors (Vidić et al. 2007).

The breeding of small ruminants is a primordial activity of the North African breeder (Rondia 2006) and is the main source of red meat in Algeria (Mebirouk-Boudechiche et al. 2014). Small ruminants are farmed under the traditional extensive system in Algeria, and intensive farming systems have recently been introduced in the country. The total number of sheep and goats in Algeria has been estimated in 2017 at 26.4 million and 4.8 million heads, respectively, which constitutes an important wealth for the country (MADR

✉ Nadjat Amina Khelifi-Ouchene  
khelifinaa@gmail.com

<sup>1</sup> Department of Veterinary Sciences, University of El Tarf, 36000 El Tarf, Algeria

<sup>2</sup> Institute of Veterinary Sciences, University Saad Dahlab of Blida 1, Street Soumaa, BP270, 09000 Blida, Algeria

<sup>3</sup> Laboratory PADESCA, Veterinary Sciences Institute, Road of Guelma, El-khroub, 25100 Constantine, Algeria

<sup>4</sup> Bordj Menaïel Hospital, Street Madaoui Ali, BP70, 35000 Boumerdes, Algeria

<sup>5</sup> Normal High School of Technological Teaching, University of Skikda, 21000 Skikda, Algeria

2018) and contribute substantially to food security, to the economy of mountain households, to their maintenance in poor and inaccessible territories, and require a human presence in regions exposed to rural exodus (Ouchene-Khelifi et al. 2015; 2018). However, the breeding of small ruminants in Algeria is subject to several constraints, including abortions. Khaled and Bouyoucef (2013) have reported that 90% of Algerian farmers had observed abortions on their farms.

Therefore, a comprehensive overview of abortive diseases in small ruminants has become crucial for the development of effective prevention and control measures and for a better prevention of human contamination since most of these diseases are zoonoses.

A recent systematic review, pertaining to small ruminants diseases (Kardjadj 2017), concluded that the epidemiological status of small ruminant diseases in Algeria is striking and the main infectious diseases threatening its small ruminant industry are peste des petits ruminants, bluetongue, foot and mouth disease, sheep pox/goat pox, brucellosis, and Rift Valley fever.

This systematic review is solely focused on the prevalence of abortion causes in sheep and goats in Algeria and its association with several risk factors.

## Material and methods

### Literature search strategy

This systematic review and meta-analysis was structured according to the recommendations of the Preferred Reporting Elements for Systematic Reviews and Meta-analysis (PRISMA; Moher et al. 2009). The study included only articles published in English that analyzed the causes of abortion infection in small ruminants in Algeria. The search was conducted using five literature databases, including PubMed, Thomson Reuters, ScienceDirect, Scopus, and Google Scholar. The search criteria were specified in advance, and was executed on April 8, 2020, and last updated on July 7, 2020. The following keywords with different combinations were used for the search: “abortion” and “brucellosis” or “*Brucella melitensis*” or “chlamydia” or “*Chlamydia abortus*” or “Q fever” or “*Coxiella burnetii*” or “Campylobacteriosis” or “*Campylobacter* spp” or “salmonellosis” or “*Salmonella* spp” or “leptospirosis” or “*Leptospira* spp” or “listeriosis” or “*Listeria* spp” or “mycoplasmosis” or “*Mycoplasma* spp” or “pestivirus” or “peste des petits ruminants (PPR)” or “bluetongue virus (BTV)” or “Border disease virus (BDV)” or “*Bovine virus diarrhea virus (BVDV)*” or “toxoplasmosis” or “*Toxoplasma gondii*” or “neosporosis” or “*Neospora caninum*” or “trichomonosis” or “*Trichomonas fetus*” or “mycosis” or “*Aspergillus* spp” and “prevalence” or

“epidemiology” and “risk factors” and “sheep” or “goat” or “small ruminants” and “Algeria.” The collected bibliographic references were screened carefully in order to eliminate duplicates. Also, the reference lists of reviews, and all the retrieved articles, were manually searched during the same period to maximize article recovery.

### Eligibility criteria

An article was included if it fulfilled the following criteria: (1) Full text in the English language published online up to July 2020; (2) descriptive or cross-sectional study (or clarity of objective/s) (estimation of prevalence or otherwise); (3) research reporting the prevalence of different abortion causes in small ruminants and their risk factors using different methods (serological examination, parasite observation, or PCR detection of NA); (4) exact total sample size, positive samples, and the study period were available. Articles were excluded when any of the above criteria were not met. We did not consider redundant articles or data, conference abstracts, and review articles.

All identified studies from the searches were independently assessed for eligibility and inclusion by two different authors. Discrepancies were resolved by discussion and consensus. If required, authors were contacted for clarifying the eligibility of papers.

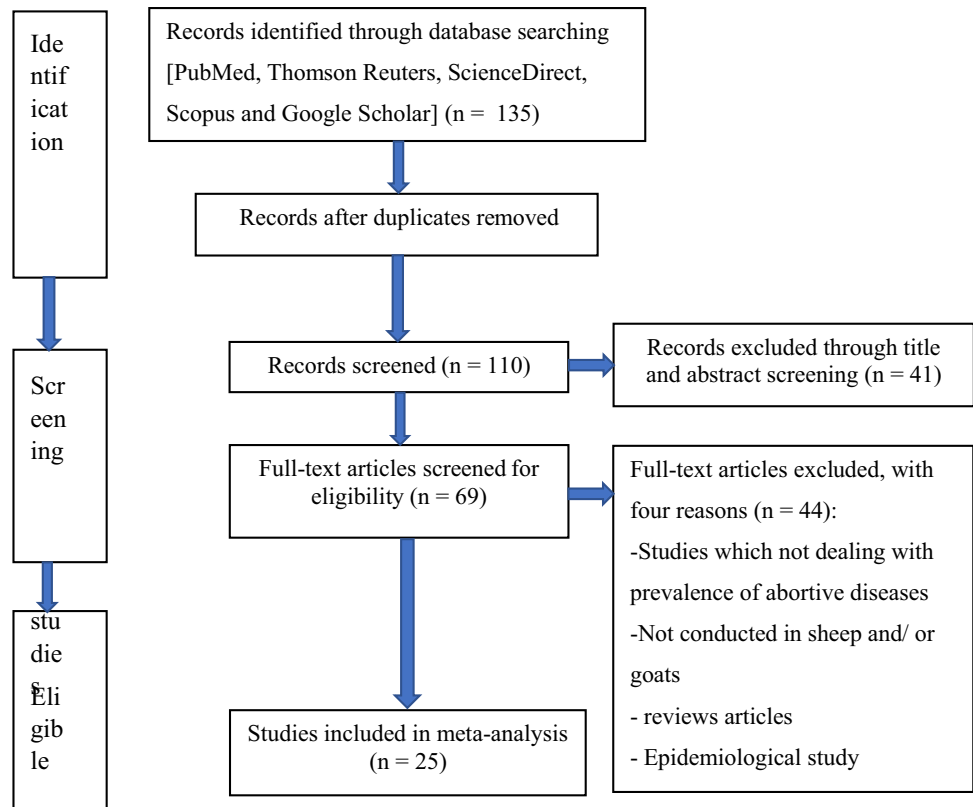
### Data extraction

A suitable data extraction template was prepared to collect and organize information from each reviewed study. The information retrieved included first author, year of publication, animal species, geographical area of study, sample size (number of examined animals), number of cases, prevalence rate, type of simple, diagnostic tests used for the study, sensitivity and specificity of diagnostic tests, risk factors, and the year in which studies were carried out. If required, authors were contacted for additional information.

## Results

### Literature search result

Through this search, 25 papers published between 2003 and 2020 were identified, eligible to be included in our systematic review and meta-analysis study. The number of articles screened, excluded, and included in the meta-analysis is shown in the diagram (Fig. 1).

**Fig. 1** Flow diagram of the selection of eligible studies

## Causes of abortion

Examination of these 25 studies revealed the existence of 10 different infectious and parasitic abortive diseases of small ruminants in Algeria, including four (4) bacterial diseases (brucellosis, chlamydiosis, Q fever, and salmonellosis), five (5) viral diseases (PPR, bluetongue, border disease, CAE, and BVDV), and one (1) parasitic cause (toxoplasmosis) (Table 1). No eligible studies were conducted on mycosis causes. Among the 25 studies, 3 reported multiple diseases (multiple pathogen survey).

The total number of small ruminants included in these 25 studies was 54,330, of which 5080 (9.35%) were reported to be diseased and/or infected with one of the 10 reported infectious or parasitic diseases. The majority of diseases/infections were diagnosed by serological and molecular tests.

## Spatial distribution of eligible studies

Out of the 25 studies, 9 (36%) were conducted in several regions across the country. Six (24%) studies were carried out in northeastern Algeria: 2 (8%) studies each in Constantine and Tebessa; 1 (4%) in Mila; and 1 (4%) study in the eastern highlands (Batna and Setif).

Five studies (20%) were conducted in north-central Algeria and the highlands: one study (4%) each in Djelfa, Tiaret,

**Table 1** Diseases categories, number of studies, and sample size of all eligible studies

Diseases categories	No. of studies (%)	Sample size (sheep and goats)
<b>Bacterial diseases</b>		
Brucellosis	06 (20)	33,205
Chlamydiosis	05 (16.66)	1809
Q fever	02 (6.66)	674
Salmonellosis	01 (3.33)	43
<b>Viral diseases</b>		
PPR	04 (13.33)	8143
Bluetongue	03 (10)	3022
Border disease	01 (3.33)	2151
CAE	01 (3.33)	105
BVDV	01 (3.33)	197
<b>Parasitic disease</b>		
Toxoplasmosis	06 (20)	4980
Total	25 (100)	54,330

PPR pest des petits ruminants, CAE caprine arthritis encephalitis, BVDV bovine viral diarrhea virus

and Ksar El-Boukhari; and 2 studies (8%) were conducted along the highlands of central Algeria.

Two studies (8%) were carried out in the north-west of the country: one study (4%) in Mostaganem and the other in Sidi Belaabes.

The other three studies (12%) were carried out in the south of the country (the Sahara) and were distributed as follows: one study (4%) in the north of the Sahara (Ghardia) and two studies (8%) in the south-west of the Sahara (Tindouf and Beni-Abbes).

### Distribution of studies over time

Examining the distribution of published studies over time, it was found that 23 studies (92%) were conducted and published from 2011 to the present. However, only two studies (8%) were published before this date.

### Determination of abortive diseases

#### Bacterial diseases

A total of 14 papers (Table 2) reported the prevalence of bacterial abortive diseases, and their risk factors in small ruminants included 4 infections: brucellosis, chlamydiosis, Q fever, and salmonellosis (Tables 1, 2). Most of these investigations were serological studies using different laboratory methods (RBPT, BAPAT, CFT, ELISA, PCR, and card test) (Table 2), while no publications have documented the prevalence of campylobacteriosis, leptospirosis, and listeriosis.

**Brucella spp.** Six papers discussed the prevalence, and the risk factors of brucellosis in small ruminants' flocks. Most of these investigations were based on serological test: 5 studies performing RBPT; 1 study performing BAPAT, 1 study performing card test, and 1 study performing ring test. The total number of individual samples was 7260 sheep and 25,945 goats. The reported prevalence ranged from 0.06 to 2.22% and from 3.05 to 68.42% in sheep and goats respectively. The overall estimated prevalence was 0.39% (0.23–0.56%; 95% CI) in sheep (21/5328) and 5.31% (5.04–5.59%; 95% CI) in goats (1354/25,456).

For the culture and the identification of *Brucella* spp., twenty-six (68.42%) bacterial isolations were characterized by Gabli et al. (2015) in goats' vaginal swabs. Only Biovar 3 *B. melitensis* strains were identified.

Risk factors associated with *Brucella* spp. seropositivity in small ruminants were identified: age, sex of animal, herd size, management system (nomadic/sedentary systems), gestation rank, and parity (Gabli et al. 2015; Kardjadj et al. 2016a, 2016b; Kouri et al. 2018).

**Chlamydia spp.** Information on *Chlamydia* infection in small ruminants was obtained from 5 studies using indirect ELISA, real-time PCR, and PCR–RFLP methods. Analysis included a total of 1809 sheep and goats. The reported seroprevalence ranged from 08.5 to 35.41%. Meta-analysis showed that the prevalence of chlamydiosis in small ruminants was 32.72% (27.61–37.82%; 95% CI). *Chlamydia abortus* (43.3%) was the species most frequently detected, followed by *C. pecorum* (20%) (Merdja et al. 2015a).

The most potential risk factors associated with chlamydiosis infection in small ruminants were age, reproductive disorders (stillbirth problem, mortality rate in young lambs, and septicemia in lambs), management system (not using disinfectants, availability of veterinary service, and visit of adjacent farm-workers), and the region (Hireche et al. 2014; Hireche et al. 2016; Abdelkadir et al. 2017).

**Coxiella burnetii** Few studies have targeted *Coxiella burnetii* infection in small ruminants. A total number of individual samples were 674 sheep and goats. The overall estimated prevalence in small ruminants was 20.62 (17.57–23.68%; 95% CI) (139/674). The first report was conducted by Khaled et al. (2016). Indirect ELISA was used to detect specific antibodies against *C. burnetii*, and real-time PCR was used to detect bacterial DNA. The survey indicated that individual seroprevalence was estimated at 14.1% and 21.3% of females have proved *C. burnetii* excretion. Abdelkadir et al. (2017) were reported a prevalence of 27.78% in aborted ewes.

**Salmonella spp.** There was only one study that treated salmonella infection in goats. Forty-three milk samples were tested using CONDA media for bacterial culture and the results were all negative.

#### Viral diseases

Viral causes have been reported in eight papers that have concerned PPRV, BTV, BDV, CAEV and BVDV (Table 3).

**Peste des petits ruminants virus (PPRV)** Four articles were revealed reporting information on the prevalence of peste des petits ruminants (PPR) in Algeria. Two (2) testing methods were used: c-ELISA and rt-PCR. The total number of investigations performed was 8134 sheep and goats of which 1282 were positive (15.76%), (14.97–16.55%; 95% CI). The prevalence varied from 10.58 to 65.62%.

Age, herd mix, and contact with other herds were the main risk factors identified (Kardjadj et al. 2015b; Baazizi et al. 2017).

**Table 2** Characteristics of the included studies concerning abortive bacterial diseases in small ruminants

Diseases	Reference	Region	Species	Sample type	Lab diagnostic	Individual level		Flock level	
						Sample size	Positive case (%)	Sample size	Positive case (%)
Brucellosis	Aggad 2003	Tiaret	Sheep	Blood	RBPT	142	06 (4.22)	-	-
	Aggad 2003	Tiaret	Goats	Blood	RBPT	230	02 (3.07)	-	-
	Aggad 2003	Tiaret	Sheep	Blood	BAPAT	142	02 (1.42)	-	-
	Aggad 2003	Tiaret	Goats	Blood	BAPAT	230	07 (3.05)	-	-
	Bachir Pacha et al. 2009	The north and the high plateaus	Sheep	Blood	Card test, CFT	4594	03 (0.06)	-	-
	Bachir Pacha et al. 2009	The north and the high plateaus	Goats	Blood	Card test, CFT	19,568	1224 (6.2)	-	-
	Gabli et al. 2015	The eastern Algerian high plateaus	Goats	Blood	RBPT, CFT	4955	49 (0.98)	101	16 (15.84)
	Gabli et al. 2015	The eastern Algerian high plateaus	Goats	Vaginal swabs	RBPT, CFT	38	26 (68.42)	-	-
	Kardjadj et al. 2016a, 2016b	Different region of the country	Sheep and goats	Blood	RBPT	2421	-	150	05 (3.33)
	Kouri et al. 2018	The arid zones of Algeria	Goats	Blood	RBPT, CFT	105	25 (23.8)	23	09 (39.1)
Kouri et al. 2018	The arid zones of Algeria	Goats	Milk	Ring test	43	6 (14)	10	03 (3.33)	
Rechidi-Sidhoum et al. 2018	Mostaganem	Sheep	Blood	RBPT, CFT	450	10 (2.22)	65	5 (7.69)	
Rechidi-Sidhoum et al. 2018	Mostaganem	Goats	Blood	RBPT, CFT	287	15 (5.23)	40	7 (17.5)	
Hireche et al. 2014	Constantine	Sheep	Blood	i-ELISA	552	135 (24.5)	54	38 (70.4)	
Hireche et al. 2014	Constantine	Sheep	Blood	i-ELISA	552	40 (7.2)	54	18 (33.3)	
Hireche et al. 2014	Constantine	Sheep	Placentas	PCR-RFLP	08	04 (50)	-	-	
Hireche et al. 2014	Constantine	Sheep	Fetuses	PCR-RFLP	10	06 (60)	-	-	
Merdja et al. 2015a	Different areas of Algeria	Sheep and goats	Blood	i-ELISA	164	14 (8.5)	20	06 (30)	

Table 2 (continued)

Diseases	Reference	Region	Species	Sample type	Lab diagnostic	Individual level		Flock level			
						Sample size	Positive case (%)	Sample size	Positive case (%)	CI (95%)	CI (95%)
Q fever	Merdja et al. 2015a	Different areas of Algeria	Sheep and goats	Vaginal swabs	rt-PCR	199	30 (15)	20	16 (64)	[10.10–20.05]	[62.47–97.53]
	Merdja et al. 2015b	The region of Ksar El-Boukhari	Sheep and goats	Blood	i-ELISA	144	51 (35.41)	17	15 (88.23)	[27.61–43.23]	[72.92–100]
Q fever	Abdelkadir et al. 2017	Sidi Belabbes	Sheep	Blood	i-ELISA	180	55 (30.56)	39	29 (74)	[23.92–37.84]	[58–86]
	Khaled et al. 2016	Different regions of Algeria	Sheep and goats	Blood	i-ELISA	227	32 (14.1)	35	17 (58)	[11.8–16.4]	[32.01–65.13]
Salmonellosis	Khaled et al. 2016	Different regions of Algeria	Sheep and goats	Genital swabs	rt-PCR	267	57 (21.3)	35	21 (60)	[16.43–26.26]	[43.77–76.23]
	Abdelkadir et al. 2017	Sidi Belabbes	Sheep	Blood	i-ELISA	180	50 (27.78)	39	28 (72)	[21.37–34.93]	[57.67–85.92]
Salmonellosis	Kouri et al. 2018	The arid zones of Algeria	Goats	Milk	Culture (CONDA media)	43	00 (00)	-	-	-	-

*RBPT* Rose Bengal plate test, *BAPAT* buffered acidified plate agglutination test, *CFT* complement fixation test, *ELISA* enzyme-linked immunosorbent assay test, *i-ELISA* indirect enzyme-linked immunosorbent assays, The antigen plugged on plate or “card test”, *rt-PCR* real-time polymerase chain reaction

**Table 3** Characteristics of the included studies concerning abortive viral diseases in small ruminants

Diseases	Reference	Region	Species	Sample type	Lab diagnostic	Sample size	Individual level		
							Positive case	Prevalence %	CI (95%)
PPRV	De Nardi et al. 2011	Tindouf	Sheep and goats	Nasal swabs, ocular swabs, whole blood	rt-PCR	09	03	33.3	[2.53–64.13]
	Kardjadj et al. 2015a	Ghardaïa	Sheep	Blood	c-ELISA	30	06	20	[5.69–34.31]
	Kardjadj et al. 2015a	Ghardaïa	Goats	Blood sera	c-ELISA	32	11	34.37	[17.92–50.83]
	Kardjadj et al. 2015a	Ghardaïa	Sheep	Blood	rt-PCR	30	6	20	[5.69–34.31]
	Kardjadj et al. 2015a	Ghardaïa	Goats	Blood	rt-PCR	32	8	25	[10.00–40.00]
	Kardjadj et al. 2015a	Ghardaïa	Sheep	Oculo-nasal swabs	rt-PCR	30	15	50	[32.11–67.89]
	Kardjadj et al. 2015a	Ghardaïa	Goats	Oculo-nasal swabs	rt-PCR	32	21	65.62	[49.17–82.08]
	Kardjadj et al. 2015b	Algeria	Sheep	Blood	c-ELISA	3336	362	10.85	[9.80–11.91]
	Kardjadj et al. 2015b	Algeria	Goats	Blood	c-ELISA	1216	214	17.59	[15.46–19.74]
	Baazizi et al. 2017	Algeria	Sheep	Blood	c-ELISA	2786	484	17.4	[15.97–18.78]
	Baazizi et al. 2017	Algeria	Goats	Blood	c-ELISA	610	152	24.9	[21.49–28.35]
BTV	Madani et al. 2011	Different regions of Algeria	Sheep	Blood	ELISA	359	52	14.48	[10.84–18.13]
	Madani et al. 2011	Different regions of Algeria	Goats	Blood	ELISA	71	15	21.12	[11.63–30.62]
	Madani et al. 2011	Different regions of Algeria	Sheep	Blood	rt-PCR	51	03	20	[0.00–12.34]
	Madani et al. 2011	Different regions of Algeria	Goats	Blood	rt-PCR	15	00	00	[0.00–0.00]
	Kardjadj et al. 2016a, 2016b	Different regions of Algeria	Sheep and goats	Blood	c-ELISA	2421	138	5.70	[4.78–6.62]
	Kouri et al. 2018	The arid zones of Algeria	Goats	Blood	c-ELISA	105	70	66.7	[57.65–75.68]
BDV	Feknous et al. 2018	Different regions of Algeria	Sheep	Blood	Ag-ELISA	689	00	00	
	Feknous et al. 2018	Different regions of Algeria	Sheep		rt-PCR	689	00	00	
	Feknous et al. 2018	Different regions of Algeria	Sheep	Blood	Ab-ELISA	576	344	60.17	

**Table 3** (continued)

Diseases	Reference	Region	Species	Sample type	Lab diagnostic	Sample size	Individual level		CI (95%)
							Positive case	Prevalence %	
	Feknous et al. 2018	Different regions of Algeria	Sheep		VNT	197	144		
CAEV	Kouri et al. 2018	The arid zones of Algeria	Goats		i-ELISA	105	00	00	
BVDV	Feknous et al. 2018	Different regions of Algeria	Sheep		VNT	197	02		

*PPRV* pest des petits ruminants virus, *BTV* bluetongue virus, *BDV* border disease virus, *CAEV* caprine arthritis encephalitis virus, *BVDV* bovine viral diarrhoea virus, *i-ELISA* indirect enzyme-linked immunosorbent assays, *c-ELISA* enzyme-linked immunosorbent assay competitive, *VNT* virus neutralization test, *rt-PCR* real-time polymerase chain reaction

**Bluetongue virus (BTV)** There were three papers published on BTV prevalence among small ruminants. The total number of sheep and goat samples was 3022. Prevalence levels ranged from 5.70 to 66.7%. The serotype identified was BTV-1. The overall estimated prevalence in sheep and goats was respectively, 13.41% (55/410) (10.12–16.71%; 95% CI) and 44.50% (85/191) (37.45–51.55%; 95% CI).

Risk factor analysis indicated that grazing system, mixed flocks, presence of wetlands nearby the flocks, and lack of *Culicoides* control strategies were the major risk factors associated with bluetongue seropositivity in Algerian small ruminants (Kardjadj et al. 2016a, 2016b).

**Border disease virus (BDV)** Information on border disease virus in sheep was obtained from one study only using four (4) different test methods (Ag-ELISA, RT-PCR, Ab-ELISA, and VNT). The total number of individual samples was 2151. The overall estimated prevalence was 22.68% (488/2151) (20.92–24.46%, 95% CI).

Several risk factors were identified as linked to BDV such as climate, landscape, flock management and presence of goats and other diseases in the farm (Feknous et al. 2018).

**Bovine viral diarrhoea virus (BVDV-1 and BVDV-2)** Prevalence of anti-BVDV antibody in sheep was obtained from one study only which was performing by VNT. The total number of individual samples was 197 and the prevalence was 1.01% (Feknous et al. 2018).

**Caprine arthritis encephalitis virus (CAEV)** One study was obtained about CAEV seroprevalence using i-ELISA

method. The study was conducted on 105 goats which were all free of CAEV (Kouri et al. 2018).

## Parasitic causes

Parasitic causes have been reported in six papers that have concerned only toxoplasmosis (Table 4). There are no data available on other parasitic causes that may induce abortion in small ruminants such as *Neospora caninum* and *Trichomonas fetus*.

Information on *Toxoplasma gondii* infection in small ruminant was obtained from 6 different studies. Four studies performing ELISA; one study performing IFAT; one study performing LAT; one study performing PCR; and one study performing histological technique. The total number of individual samples was 3938 sheep and 1042 goats. *T. gondii* infection prevalence among sheep and goats was 21.43% (844/3938) (20.15–22.71%, 95% CI) and 32.31% (337/1043) (29.47–35.15%; 95% CI) respectively.

The main risk factors associated with toxoplasma infection were age, sex, region, season management system (herd size, presence of goats in sheep flocks) (Dechicha et al. 2015; Dahmani et al. 2018; Benlakehal et al. 2019; Mohamed-Cherif et al. 2019; Ait Issaad et al. 2020), and reproductive disorders (abortion stage, and flocks with a history of abortion) (Benlakehal et al. 2019; Dahmane et al. 2020; Ait Issaad et al. 2020).



**Table 4** Characteristics of the included studies concerning abortive parasitic diseases in small ruminants

Disease	Reference	Region	Species	Simple	Lab diagnostic	Individual level		Flock level			
						Total animals	Positive case (%)	CI (95%)	Total animals	Positive case (%)	CI (95%)
<i>Toxoplasma gondii</i>	Dechicha et al. 2015	Djelfa	Sheep	Blood serum	IFAT	276	32(11.59)	[8.07–15.97]	19	11 (57.89)	36.28–76.86
	Dechicha et al. 2015	Djelfa	Goats	Blood serum	IFAT	106	14 (13.21)	[7.41–21.17]	6	04 (66.66)	30–90.32
	Dahmani et al. 2018	The north of Algeria	Sheep	Blood serum	ELISA	580	48 (8.28)	[6.03–10.52]	-	-	-
	Dahmani et al. 2018	The north of Algeria	Sheep	Esophagi and dia-phragms	Histological technique	335	02 (0.59)	[0.00–1.42]	-	-	-
	Benlakehal et al. 2019	Tebessa	Sheep	Blood serum	i-ELISA	376	133 (35.37)	[30.54–40.21]	39	33 (84.61)	73.29–95.94
	Mohamed-Cherif et al. 2019	The central of Algeria	Sheep	Blood serum	i-ELISA	2144	549 (25.6)	[23.8–27.4]	70	70 (100)	10–100
	Mohamed-Cherif et al. 2019	The central of Algeria	Goats	Blood serum	i-ELISA	478	57 (11.9)	[9–14.8]	47	41 (87.2)	77.7–96.8
	Dahmane et al. 2020	Mila	Goats	Blood serum	i-ELISA	184	132 (71.73)	[64–79.4]	25	24 (96)	83.30–99.92
	Dahmane et al. 2020	Mila	Goats	Blood serum	LAT	184	117 (63.58)	[56.43–70.20]	25	25 (100)	78.58–99.21
	Ait Issaad et al. 2020	Tebessa	Sheep	Blood	PCR	227	80 (35.24)	[29.03–41.46]	20	-	-
	Ait Issaad et al. 2020	Tebessa	Goats	Blood	PCR	91	17 (18.68)	[10.67–26.69]	20	-	-

IFAT indirect fluorescent antibody test, ELISA enzyme-linked immunosorbent assay, i-ELISA indirect enzyme-linked immunosorbent assay, LAT latex agglutination test, PCR: polymerase chain reaction

## Discussion

Abortion in small ruminants can be caused by a variety of infectious and non-infectious agents. It can cause great economic losses (Givens and Marley 2008; Holler 2012). Despite preventive recommendations made by veterinarians of the State for several years, abortion in small ruminants remains a difficult problem in Algeria. The first publication on the causes of abortions in small ruminants in Algeria was published in 2003 which concerned brucellosis (Aggad 2003) and since then no study has been carried out until 2009 when a study on the same pathology was published (Bachir Pacha et al. 2009).

To the best of our knowledge, this systematic review is the first in Algeria which provides a comprehensive concept regarding the etiology of abortions in small ruminants through the pooling of data from studies published from the beginning in 2003 to 2020. A total of 25 studies were eligible for this review which included a number of 54,330 small ruminants of which 5080 were revealed positive (9.35%). The review indicates that there was very little research on abortive infectious and parasitic diseases of sheep and goats until 2011 when a marked increase in prevalence studies was noted.

The prevalence of different abortion diseases varies according to the studies. This difference could be attributed to several factors, the most important of which are difference in sampling technique, herd management, and the climate and diagnostic test used (Selim et al. 2018a; Tesfaye et al. 2020; Mamlouk et al. 2020).

Chlamydia and Q fever were observed in 32.72% and 20.62% of small ruminants, respectively. The prevalence of peste des petits ruminants was 15.76% and the overall prevalence of bluetongue in sheep and goats was, respectively, 13.41% and 44.50%. *Toxoplasma gondii* infection prevalence among sheep and goats was 21.43% and 32.31% respectively. Border disease and bovine viral diarrhoea were detected in 22.68% and 1.01% of sheep examined, respectively. The overall prevalence of brucellosis was 0.39% in sheep and 5.31% in goats. All samples were found to be free of salmonellosis and *Caprine arthritis encephalitis virus* (CAEV).

*Chlamydia abortus*, causing enzootic abortion in sheep, is considered one of the major causes of abortion in small ruminants worldwide (Tejedor-Junco et al. 2019). Abortion is observed in particular during the last 2 or 3 weeks of gestation (Arif et al. 2020). The prevalence reported herein ranges from 08.5 to 35.41% with an average of 32.72%, which is in agreement with the previous prevalence of 27.2% in Morocco (Benkirane et al. 2015), 14.9% in Egypt (Selim et al. 2018a), 21.8% in Jordan (Al-Qudah et al. 2014), and 21.5% in Brazil (Pinheiro Junior et al. 2010). It is higher than

that reported in other studies in Tunisia: 1.9% (Rekiki et al. 2005), 6.6% (Mamlouk et al. 2020), and 3.2% (Elandalousi et al. 2015).

The prevalence of *Border disease virus* (BDV) revealed herein is lower than reported elsewhere (Valdazo-Gonzalez et al., 2006; Krametter-Froetscher et al. 2010; Martin et al. 2015; Mishra et al. 2016). There are significant regional variations in the prevalence of the disease in small ruminants which are attributed to the levels of movement, regional differences in management practices, and herd density (Nettleton et al. 1992).

Toxoplasmosis, due to *Toxoplasma gondii*, is one of the major parasitic causes of reproductive failure associated with abortion, in sheep and goats (Weiss and Dubey 2009). The prevalence of toxoplasma-infection in small ruminants depends on the density of infected cats around the farm, the breeding conditions, the climate, the diagnostic technique used, and the sampling procedure (Liu et al. 2015; Hanif and Tasawar 2016; Tegegne et al. 2016). The reported prevalence in sheep (21.43%) is comparable to those previously recorded in Morocco (20.8%) (Benkirane et al. 2015) and Tunisia (19%) (Gharbi et al. 2013), but higher than those reported in Pakistan (11.1%) (Ramzan et al. 2009) and northeast China (3.0%) (Wang et al. 2011). Higher values were observed in Tunisia (40.2%) (Lachkhem and Sakly 2015), Egypt (52.7%) (Ibrahim et al. 2017), and Morocco (27.6%) (Sawadogo et al. 2005). In goats, prevalence of *T. gondii* infection observed in this study was close to that recorded in Tunisia (34%) (Lachkhem and Sakly 2015), and higher than that observed in Morocco (8.5%) (Benkirane et al. 2015), Pakistan (11.2%) (Ramzan et al. 2009), and central Ethiopia (11.6%) (Bekele and Kasali 1989). Other reports have shown higher prevalences than ours, such as those from Pakistan (41.8%) (Ahmed et al. 2016), Egypt (44.3%) (Shaapan et al. 2010), and southern Ethiopia (55.18%) (Tegegne et al. 2016).

*Coxiella burnetii*, is an obligate intracellular bacterium, which causes Q fever disease responsible for reproductive disorders such as abortion in ruminants (Elhaig et al. 2018). According to published data, the prevalence of Q fever in sheep and goats in Algeria was 20.62%, which is in agreement with 22.7% in Egypt (Selim et al. 2018b) and inferior to the results of Kalender (2001) who reported a prevalence of 38.59% in Turkey. Low results were recorded by Kilic and Kalender (2016) in Turkey (16% in aborted ewes and 7.6% in non-aborted ewes).

Bluetongue is an infectious viral disease of domestic and wild ruminants. It is transmitted between ruminants by the bite of *Culicoides* midge vectors (Breard et al. 2004; Kaufmann et al. 2012). In the present study, the prevalence of BTV was 13.41% in sheep which is lower than the reported prevalence of 39.4% in Thailand (Apiwatnakhorn

et al. 1996) and 90% in Turkey (Taylor et Mellor 1994) and higher than 6.57% in southeastern Iran (Mozaffari and Khalili 2012). The prevalence of BTV herein was 44.50% in goats which is lower than the reported prevalence of 73.0% in Thailand (Apiwatnakorn et al. 1996) and higher than the result of 3.9% in Brazile (Mota et al. 2011).

Peste des petits ruminants (PPR), is a highly contagious viral disease of small ruminants in many countries in Africa, the Middle East, and Asia. It has been reported by FAO and OIE as a class one disease to be eradicated (OIE and FAO, 2015). In Algeria, PPR has been reported only in sheep with a prevalence of 14.05%, which is significantly lower than other studies (Dhar et al. 2002; Ozkul et al. 2002; Khan et al. 2011 in Pakistan).

Bovine viral diarrhoea virus (BVDV-1 and BVDV-2) has been identified in Algeria in sheep with a low prevalence (1.01%) which is much lower than the results of other studies (O'Neill et al. 2004; Valdazo-Gonzalez et al. 2006; Gaffuri et al. 2006).

Brucellosis is an important zoonosis that causes massive economic losses in small ruminant farming with great public health significance. In sheep and goats, it is mainly caused by *Brucella melitensis* of which the main symptom is abortion (Celli and Gorvel 2004). In Algeria, the prevalence revealed in this systematic review and meta-analysis in goats and sheep was 5.32% and 0.39% respectively, which is largely lower than reported elsewhere (Mrunalini et al. 2000 and Singh et al. 2000 performed in India; Al-Dabagh et al. 2014 and Tamadhir et al. 2020 performed in Iraq).

## Conclusion

This meta-analysis is the first synthesis study on abortive diseases in small ruminants in Algeria. It provides important information that could be useful in managing and monitoring programs to control abortive diseases in small ruminants. The main abortive diseases in small ruminants in Algeria are brucellosis, chlamydiosis, Q fever, salmonellosis, PPR, bluetongue, border disease, CAE, BVDV, and toxoplasmosis. Considering that some of these diseases are zoonoses, farmers must take important hygienic precautionary measures. Further research and surveillance will be needed to reduce the prevalence of these infections and, consequently, reduce economic damage and public health risks in Algeria.

**Author contributions** All authors read and approved the final manuscript.

**Data availability** All data generated or analyzed during this study are included in this published article.

## Declarations

**Ethics approval** Not applicable.

**Conflict of interest** The authors declare that they have no competing interests.

## References

- Abdelkadir, K., Khatima, A. O., and Djamel, K., 2017. Seroprevalence of chlamydial abortion and Q fever in ewes aborted in the North-West of Algeria. *Journal of Veterinary Medicine and Animal Health*, 9(9), 246-249. <https://doi.org/10.5897/JVMAH2016.0474>
- Aggad, H., 2003. Serological studies of animal brucellosis in Algeria. *Assiut Veterinary Medical Journal*. 49(98), 121-130.
- Ahmed, H., Malik, A., Arshad, M., Mustafa, I., Khan, M.R., Afzal, M.S., Ali, S., Mobeen, M., and Simsek S., 2016. Seroprevalence and spatial distribution of toxoplasmosis in sheep and goats in North-Eastern Region of Pakistan. *Korean Journal of Parasitology*. 54:439. <https://doi.org/10.3347/kjp.2016.54.4.439>
- Ait Issaad, N., Abdelouahed, K., Bekhouche, S., Boubeuker, R., Adjemi, H., Ouchene-Khelifi, N.A., Ouchene, N., Oudhia, K., and Khelef, D., 2020. Molecular detection of the B1 gene of *Toxoplasma gondii* in blood samples of female sheep and goats in Tebessa, northeastern Algeria. *Comparative Immunology, Microbiology and Infectious Diseases*, 72,101530. <https://doi.org/10.1016/j.cimid.2020.101530>
- Al-Dabagh, I.I., Jasim, B.M., and Jarjees, M.T., 2014. Seroprevalence of antibodies to toxoplasmosis, brucellosis and chlamydiosis in abortive sheep in Nineveh governorate, Iraq. *Iraqi Journal of Veterinary Sciences*. 28, 1, (21-25)
- Al-Qudah, K., Sharif, L., Raouf, R., Hailat, N., and Al-Domy, F., 2004. Seroprevalence of antibodies to *Chlamydia abortus* shown in Awassi sheep and local goats in Jordan. *Veterinarni Medicina-UZPI (Czech Republic), Veterinarni Medicina; Prague Vol. 49, N° 12,(2004): 460-466. DOI:10.17221/5740-VETMED*
- Apiwatnakorn, B., Bura, P., Pasavorakul, O., 1996. Serological study for bluetongue in Thailand. In: George TD, Kagao P, editors. *First Southeast Asia and pacific regional bluetongue symposium*. Kunming, P. R. China: pp. 20–22.
- Arif E.D., Saeed N.M., and Rachid S.K., 2020. Isolation and identification of *Chlamydia abortus* from aborted ewes in Sulaimani Province, Northern Iraq. *Pol. Journal of Microbiology*. 69 (1), 65
- Lachkhem, I.L., and Sakly, D.S., 2015. Prevalence of Toxoplasmosis in Sheep, Goats and Cattle in Southern Tunisia. *Journal of Bacteriology and Parasitology*. 6:5. <https://doi.org/10.4172/2155-9597.1000245>.
- Baazizi, R., Khelef, D., and Hussain, T., 2017. Peste des petits ruminants in Algeria: Viral circulation of PPRV between 2012 and 2015. *Journal of Animal and Plant Science*. 27(5): 1522-1527. <https://doi.org/10.1371/journal.pone.0175461>
- Bachir-Pacha, M., Kechih, S., Berber, A and Triki-Yamani, R.R., 2009. An Inquiry about ruminants' epidemiologic brucellosis in some Algerian departments, *Bulletin UASVM Veterinary Medicine*, 66, 370–375. <https://doi.org/10.15835/buasvmcn-vm:66:2:4243>
- Bekele, T., and Kasali, O.B., 1989. Toxoplasmosis in sheep, goats and cattle in central Ethiopia. *Veterinary Research. Commun*. 13:371–375. <https://doi.org/10.1007/BF00346069>.
- Benkirane, A., Essamkaoui, S., El Idrissi, A., Lucchese, L., and Natale, A., 2015. A serosurvey of major infectious causes of abortion in small ruminants in Morocco. *Veterinaria Italiana*. 51:25–30.

- Benlakehal, A., Miroud, K., Djeghim, H., and Kaidi, R., 2019. Serological survey for anti-Toxoplasma gondii antibodies in sheep of northeastern Algeria. *Tropical Animal Health and Production*, 51(8), 2227–2233. <https://doi.org/10.1007/s11250-019-01921-2>
- Breard, E., Hamblin, C., Hammoumi, S., Sailleau, C., Dauphin, G., and Zientara, S., 2004. The epidemiology and diagnosis of bluetongue with particular reference to Corsica. *Research Veterinary Science*. 77:1–8.
- Celli, J., and Gorvel, J.P., 2004. Organelle robbery: *Brucella* interactions with the endoplasmic reticulum. *Current Opinion in Microbiology*. 7 (1): 93–97.
- Dahmane, A., Boussena, S., Hafsi, F., and Ghalmi, F., 2020. Serological Survey and Associated Risk Factors on Toxoplasma gondii Infection in Goats in Mila District, Algeria. *Folia Veterinaria*, 64(1), 48–59. <https://doi.org/10.2478/fv-2020-0007>
- Dahmani, A., Harhoura, K., Aissi, M., Zenia, S., Hamriouri, B., Guechi, N., Ait Athmane, M., and Kadour, R., 2018. The zoonotic protozoan of sheep carcasses in the north of Algeria: A case of ovine toxoplasmosis. *Journal of the Hellenic Veterinary Medical Society*, 69(2), 1004–1012. <https://doi.org/10.12681/jhvms.18385>
- De Nardi, M., Saleh S.M.L., Batten C., Oura C., Di Nardo A., and Rossi D., 2012. First Evidence of Peste des Petits Ruminants (PPR) Virus Circulation in Algeria (Sahrawi Territories): Outbreak Investigation and Virus Lineage Identification. *Transbound and Emer. Disease*. 59(3): 214–222. <https://doi.org/10.1111/j.1865-1682.2011.01260.x>
- Dechicha, A.S., Bachi, F., Gharbi, I., Gourbdji, E., Baazize-Ammi, D., Brahim-Errahmani, M., and Guetarni, D., 2015. Sero-epidemiological survey on toxoplasmosis in cattle, sheep and goats in Algeria. *African Journal of Agricultural Research*, 10(20), 2113–2119. <https://doi.org/10.5897/AJAR2015.9575>
- Dhar, P., Sreenivasa, B., Barrett, T., Corteyn, M., Singh, R. and Bandyopadhyay, S., 2002. Recent epidemiology of Peste des petits ruminant virus (PPRV). *Veterinary Microbiology*. 88: 153–159. [https://doi.org/10.1016/S0378-1135\(02\)00102-5](https://doi.org/10.1016/S0378-1135(02)00102-5)
- Elandalousi, R., Ghram, A., Maaroufi, A., and Mnif, W., 2015. Séro-prévalence des maladies abortives zoonotiques chez les ruminants au nord de la Tunisie. *Research*. 2, 1419.
- Elhaig, M.M., Selim, A., Mandour, A.S., Schulz C., and Hoffmann B., 2018. Prevalence and molecular characterization of peste des petits ruminants virus from Ismailia and Suez, Northeastern Egypt, 2014–2016. *Small ruminant Research*. 169, 94–98. <https://doi.org/10.1016/j.smallrumres.2018.07.001>
- Entrican G, Wattedegera S, Rocchi M, Wheelhouse N, 2009. Pregnancy, indoleamine 2,3-dioxygenase (IDO) and chlamydial abortion: An unresolved paradox. *Veterinary Microbiology*, Volume 135, Issues 1–2, 2009, P 98–102. <https://doi.org/10.1016/j.vetmic.2008.09.028>.
- Feknous, N., Hanon, J.B., Tignon, M., Khaled, H and Bouyoucef, A., 2018. Seroprevalence of border disease virus and other pestiviruses in sheep in Algeria and associated risk factors. *BMC Veterinary Research*. 14(1):339. <https://doi.org/10.1186/s12917-018-1666-y>
- Gabli, A., Agabou, A. and Gabli, Z., 2015. Brucellosis in nomadic pastoralists and their goats in two provinces of the eastern Algerian high plateaus. *Tropical Animal Health and Production*. 47, 1043–1048. <https://doi.org/10.1007/s11250-015-0825-4>
- Gaffuri, A., Giacometti, M., Tranguillo, V.M., Magnino, S., Cordioli, P., Lanfranchi, P., 2006. Serosurvey of roe deer, chamois and domestic sheep in the Central Italian Alps. *Journal of Wildlife Disease*, 42, 685–690.
- Gharbi M., Zribi L., Jedidi M., Chakkhari H., Hamdi S., R'hayem S., Zribi N., Souli M., and Darghouth, M.A., 2013. Prévalence d'infection des ovins par *Toxoplasma gondii* en Tunisie. *Bulletin de la Société de Pathologie Exotique*. 106:184–187. <https://doi.org/10.1007/s13149-013-0290-4>.
- Givens, M. D., & Marley, M. S. D. 2008. Infectious causes of embryonic and fetal mortality. *Theriogenology*, 70(3), 270–285.
- Hanif, M., and Tasawar Z., 2016. Seroprevalence and risk factors associated with toxoplasmosis in sheep in Multan and Khanewal districts of Punjab (Pakistan), *Journal of Animal Plant Science*. 26 (6) 1620–1627.
- Hanif, M., Tasawar, Z. 2016. Hematological and Serum Biochemical Changes in Sheep Naturally Infected with *Toxoplasma gondii* in Southern Punjab (Pakistan)., *Pakistan Journal of Life & Social Sciences*. 14(1), 52–56.
- Hireche, S., Bouaziz, O., Djennad, D., Boussen, S., Imgur, R., Kabouia, R., and Bererhi, E., 2014. Seroprevalence and risk factors associated with Chlamydia spp. infection in ewes in the northeast of Algeria. *Tropical Animal Health and Production*. 46:476–473. <https://doi.org/10.1007/s11250-013-0515-z>
- Hireche, S., Ababneh, M.M.K., Bouaziz, O. et al. 2016. Seroprevalence and molecular characterization of Chlamydia abortus in frozen fetal and placental tissues of aborting ewes in northeastern Algeria. *Trop Anim Health Prod* 48, 255–262. <https://doi.org/10.1007/s11250-015-0944-y>
- Holler, L. D. 2012. Ruminant abortion diagnostics. *Veterinary Clinics of North America-Food Animal Practice*, 28(3), 407.
- Ibrahim, H.M., Mohamed, A.H., El-Sharaawy, A.A., and El-Shanqery, H.E., 2017. Molecular and serological prevalence of *Toxoplasma gondii* in pregnant women and sheep in Egypt. *Asian Pac. Journal of Tropical Medicine*. 10:996–1001. <https://doi.org/10.1016/j.apjtm.2017.09.012>.
- Kalender, H., 2001. The incidence of *Coxiella burnetii* infection in ewes in Elazığ and neighbouring provinces. *Turkish Journal of Veterinary and Animal Science*. 25:51–55.
- Karaca, M, Babur, C, Celebi, B, Akkan, H A, Tutuncu, M, Keles, I, Uslu, B A, and Kilic, S., 2007. Investigations on seroprevalence of toxoplasmosis, listeriosis and brucellosis in goats living in the region of Van, Turkey. *YYU Fac Derg*. 18:45–49.
- Kardjadj, M., Ben-Mahdi, M.H., and Pam, D.L., 2015a. First serological and molecular evidence of PPRV occurrence in Ghardaïa district, center of Algeria. *Tropical Animal Health and Production*. <https://doi.org/10.1007/s11250-015-0860-1>.
- Kardjadj, M., Metref, D., Kouidri, B., Luka, P.D., Ben-Mahdi, M.H., 2015b. Seroprevalence distribution and risk factor for Peste des Petits Ruminants (PPR) in Algeria. *Preventive Veterinary Medicine*. <https://doi.org/10.1016/j.prevetmed.2015.09.002>
- Kardjadj, M., Kouidri, B., Metref, D., Luka, P.D. and Ben-Mahdi M.H., 2016a. Abortion and various associated risk factors in small ruminants in Algeria. *Prev. Vet. Med.*, 123, 97–101. <https://doi.org/10.1016/j.prevetmed.2015.11.015>
- Kardjadj, M., Luka, P.D. and Ben-Mahdi, M.H., 2016b. Sero-epidemiology of bluetongue in Algerian ruminants. *African Journal of Biotechnology*. 15 (20), 868–871. <https://doi.org/10.5897/AJB2016.15343>
- Kardjadj, M., 2017. An epidemiological overview of small ruminant diseases in Algeria. *Rev Sci Tech OIE*, 36, pp.997–1006. <https://doi.org/10.20506/rst.36.3.2731>
- Kaufmann, C., Steinmann, I.C., Hegglin, D., Schaffner, F., Mathis, A., 2012. Spatio-temporal occurrence of *Culicoides* biting midges in the climatic regions of Switzerland, along with large scale species identification by MALDI-TOF mass spectrometry. *Parasite and Vectors*. 5:1–10.
- Khaled, H., and Bouyoucef, A., 2013. Assessment of zoonotic risks associated with ruminant abortions for Algerian farmers. *Bull. UASVM Vet. Med*. 70 (2), 253–257. <https://doi.org/10.15835/buasvmcn-vm:70:2:9202>

- Khaled, H., Sidi-Boumedine, H., Merdja, S., Dufour, P., Dahmani, A., Thiéry, R., Rousset, E., and Bouyoucef, A., 2016. Serological and molecular evidence of Q fever among small ruminant flocks in Algeria. *Comparative Immunology Microbiology Infectious Disease*. 47:19-25. <https://doi.org/10.1016/j.cimid.2016.05.002>
- Khan, H.A., Rahman, S., Khan, A. and Khan, Q.M., 2011. Detection and sequencing of field isolates of Pest Des Petits Ruminant virus from Punjab province, Pakistan. *Pakistan Journal of Life Science*. 11: 212-217.
- Kilic, A., and Kalender, H., 2016. A study of the correlation between *Coxiella burnetii* seropositivity and abortions in sheep in Eastern and Southeastern Turkey. *Indian Journal of Animal Research*. 50: 401-405.
- Kouri, A., Charallah, S., Kouri, F., Amirat, Z and Khammar, F., 2018. Reproductive performances and abortion etiologies of native Bedouin goats in the arid zones of Algeria. *Livestock Research for Rural Development*. 30, Article:127. <http://www.lrrd.org/lrrd30/7/schar30127>
- Krametter-Froetscher, R, Duenser, M, Preyler, B, Theiner, A, Benetka, V, Moestl, K, et al., 2010. Pestivirus infection in sheep and goats in West Austria. *Veterinary Journal*. 186:342-6.
- Liu, Q., Wang, Z.D., Huang, S.Y., and Zhu, X.Q., 2015. Diagnosis of toxoplasmosis and typing of *Toxoplasma gondii*, *Parasite and Vectors*. 8, 292, 10.1186%2Fs13071-015-0902-6
- Madani, H., Casal, J., Alba, A., Allepuz, A., Cêtre-Sossah, C., Hafsi, L., and Napp, S., 2011. Animal Diseases Caused by Orbiviruses, Algeria. *Emerging Infectious Disease*. 17:2325-2327. <https://doi.org/10.3201/eid1712.110928>
- MADR, Ministère de l'Agriculture et du Développement Rural, 2018. statistiques agricoles, [madr.gov.dz](http://madr.gov.dz).
- Rondia P., 2006. Aperçu de l'élevage ovin en Afrique du Nord. *Filière Ovine Caprine* (18) : 11-14
- Mamlouk, A., Guesmi K., Ouertani, I., Kalthoum, S., Selmi, R., Aicha, E.B., Mohamed, B.B.H., Gharbi, R., Lachtar, M., and Dhaouadi A., 2020. Seroprevalence and associated risk factors of *Chlamydia abortus* infection in ewes in Tunisia, *Comparative Immunology and Microbiology and Infectious Diseases*. Article 101500
- Martin, C, Duquesne, V, Adam, G, Belleau, E, Gauthier, D, and Champion, JL, 2015. Pestivirus infections at the wild and domestic ruminants interface in the French southern Alps. *Veterinary Microbiology*. 175:341-8.
- Mrunalini, N., Sastry, P.R., Pandarinadh, G.N., 2000. Control of brucellosis epidemic in goats in a farm." *Indian Veterinary Journal*. 77, 11 : 932-935.
- Mebirouk-Boudechiche, L., Boudechiche, L., Ferhat, R., and Tahar, A., 2014. Relation entre disponibilité en herbe, ingestion et activité de béliers au pâturage. *Archivos de Zootecnia*. 63 (242) : 277-287, doi : <https://doi.org/10.4321/S0004-05922014000200006>
- Merdja, S. E., Khaled, H., Aaziz, R., Vorimore, F., Bertin, C., Dahmani, A., and Laroucau, K., 2015a. Detection and genotyping of *Chlamydia* species responsible for reproductive disorders in Algerian small ruminants. *Tropical Animal Health and Production*, 47(2), 437-443. <https://doi.org/10.1007/s11250-014-0743-x>
- Merdja, S-E., Khalid, H., Dahmani, A., and Bouyoucef, A., 2015b. Chlamydial abortion in Algerian small ruminants. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca*. 72(1):23-26. <https://doi.org/10.15835/luasvmcn-v:10283>
- Mishra, N, Rajukumara, K, Vilcek, S, Kalaiyarasua, S, Beheraa, SP, and Dubeya, P, 2016. Identification and molecular characterization of border disease virus (BDV) from sheep in India. *Comparative Immunology and Microbiology Infectious Diseases*. 44:1-7
- Mohamed-Cherif, A., Miroud, K., Benfodil, K., Ansel, S., Khelef, D., Kaidi, D., and AitOudhia, K., 2019. Cross Sectional Survey on *Toxoplasma gondii* Infection in Cattle, Sheep, and Goats in Algeria: Seroprevalence and Risk Factors. *Veterinary Science*. 6 (3) 63. <https://doi.org/10.3390/vetsci6030063>
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., and PRISMA Group. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine*, 6, e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Mota, I.O.; Castro, R.S.; Alencar, S.P.; Lobato, Z.I.P.; Lima Filho, C.D.F.; Araújo Silva, T.L.; Dutra, A.C.T.; and Nascimento, S.A., 2011. Anticorpos contra o vírus do grupo da língua azul em caprinos e ovinos do sertão de Pernambuco e inferência sobre sua epidemiologia em regiões semiáridas. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, Belo Horizonte. 63, 6, 1595-1598. <https://doi.org/10.1590/S0102-09352011000600045>
- Mozaffari, A., and Khalili, M., 2012. The first survey for antibody against bluetongue virus in sheep flocks in southeast of Iran. *Asian Pacific Journal of Tropical Biomedicine*. S1808-S1810.
- Nettleton, PF, Gilmour, JS, Herring, AJ, Sinclair, AJ., 1992. The production and survival of lambs persistently infected with border disease virus. *Comparative Immunology and Microbiology Infectious Diseases*. 15(3):179-88
- Office of International Epizootics and Food and Agriculture Organization, 2015. Global strategy for control and eradication of PPR. FAO and OIE International conference for the control and eradication of Peste des petits ruminants (PPR). Abidjan, Cote D. Ivoire. pp. 1- 83
- O'Neill, R.G., O' Connor, M., and O' Reilly, P.J., 2004. A survey of antibodies to pestivirus in sheep in the Republic of Ireland. *Irish Veterinary Journal*, 57, 525-530.
- Ouchene-Khelifi, N.A., Ouchene, N., Da Silva, A. and Lafri, M., 2018. Multivariate characterization of phenotypic traits of Arabia, the main Algerian goat breed. *Livestock Research for Rural Development*. 30 (7)
- Ouchene-Khelifi, N.A., Ouchene, N., Maftah, A., Da Silva, A.B., and Lafri, M., 2015. Assessing admixture by multivariate analyses of phenotypic differentiation in the Algerian goat livestock. *Tropical Animal Health and Production*. 16 <https://doi.org/10.1007/s11250-015-0869-5>
- Ozkul, A., Akca, Y., Alkan, F., Barrett, T., Karaoglu, T., Dagalp, S.B. anderson, J., Yesilbag, K., Cokcaliskan, C., Gencay, A. and Burgu, I., 2002. Prevalence, distribution, and host range of peste des petits ruminant viruses. *Turkey Emerging Infectious Diseases*. 8: 708- 712. <https://doi.org/10.3201/eid0807.010471>
- Pinheiro Junior, J.W., Mota, R.A., Piatti, R.M., Oliveira, A.A.d.F., Silva A.M.d., Abreu, S.R.d.O., G. Anderlini, A., Valença, R.M.B., 2010. Seroprevalence of antibodies to *Chlamydia abortus* in ovine in the State of Alagoas, Brazil. *Brazilian Journal of Microbiology*, 41, 358-364
- Ramzan, M., Akhtar, M., Muhammad, F., Hussain, I., Hiszczyńska-Sawicka, E., Haq, A.U., Mahmood, M.S., and Hafeez, M.A., 2009. Seroprevalence of *Toxoplasma gondii* in sheep and goats in Rahim Yar Khan (Punjab), Pakistan. *Tropical Animal Health and Production*. 41:1225. <https://doi.org/10.1007/s11250-009-9304-0>.
- Rechidi-Sidhoum, N., Niar, A., Nemmiche, S. and Homrani, A. 2018. Serological diagnosis of brucellosis at the ruminants in Mostaganem (Algeria). *International Journal Bioscience*. 12(5): 271-278. <https://doi.org/10.12692/ijb/12.5.271-278>
- Rekiki, A., Thabti, F., Dlissi, I., Russo, P., Sanchis, R., Pepin, M., Rodolakis, A., and Hammami, S., 2005. Seroprevalence survey of major infectious abortive diseases in small ruminants in Tunisia, *Revue de Médecine Vétérinaire*. 156 (7) 395-401.
- Sawadogo, P., Hafid, J., Bellele, B., Sung, R.T.M., Chakdi, M., Flori, P., Raberin, H., Hamouni, I.B., Chait, A., Dalal, A., 2005. Seroprevalence of *T. gondii* in sheep from Marrakech, Morocco. *Veterinary Parasitology*. 130:89-92. <https://doi.org/10.1016/j.vetpar.2005.03.025>.

- Selim, A., Elhaig, M., Moawed, S., 2018a. A Serological Survey of Four Abortifacient Infectious Agents among Small Ruminant in Egypt. *Asian Journal of Animal Veterinary Advances*. 13 (2), 114-121
- Selim, A., Yang, E., Rousset, E., Thiéry, R., Sidi-Boumedine, K., 2018b. Characterization of *Coxiella burnetii* strains from ruminants in a *Galleria mellonella* host-based model, New microbes and new infections. 24, 8-13. <https://doi.org/10.1016/j.nmni.2018.02.008>
- Shaapan, R.M., Hassanain, M.A., Khalil, F.A.M., 2010. Modified Agglutination Test for Serologic Survey of *Toxoplasma gondii* Infection in Goats and Water Buffaloes in Egypt. *Research Journal of Parasitology*. 5:13–17.
- Singh, S.V, Agarwal, G.S, Batra, H.V, Gupta, V.K, Singh N., 2000. Monitoring of *Brucella* infection associated with reproductive losses using multiple serological tests in organized goat and sheep flocks. *Indian Journal of Animal Science*. 70(2):154–156
- Tamahir, A., Al-Ahmed, A., Salman Sufian, S., 2020. seroprevalence of enzootic abortion and border disease in small ruminants in al-basra province, IRAQ. *Plant Archives*. 20, 2, 2722-2727.
- Taylor, W.P., and Mellor, P.S., 1994. Bluetongue virus distribution in Turkey 1978-1981. *Epidemiology Infection*. 112:623–633.
- Tegegne, D., Kelifa, A., Abdurahaman, M., and Yohannes, M., 2016. Seroepidemiology and associated risk factors of *Toxoplasma gondii* in sheep and goats in Southwestern Ethiopia, *BMC Veterinary Research*. 12, 280, <https://doi.org/10.1186/2Fs12917-016-0906-2>
- Tejedor-Junco, M.T., González-Martín, M., Corbera, J.A., Santana, Á., Hernández, C.N., Gutiérrez, C., 2019. Preliminary evidence of the seroprevalence and risk factors associated with *Chlamydia abortus* infection in goats on the Canary Islands, Spain. *Tropical Animal Health Production*. 51 (1), 257-260
- Tesfaye, A., Sahele, M., Sori, T., Guyassa, C., Garoma, A., 2020. Seroprevalence and associated risk factors for chlamydiosis, coxiellosis and brucellosis in sheep and goats in Borana pastoral area, southern Ethiopia. *BMC Veterinary Research*. 16, 1-8
- Valdazo-Gonzalez, B., Alvarez-Martinez, M., and Greiser-Wilke, I., 2006. Genetic typing and prevalence of Border disease virus (BDV) in small ruminant flocks in Spain. *Veterinary Microbiology*, 117, 141–153. <https://doi.org/10.1016/j.vetmic.2006.06.008>
- Vidić, B., Savić-Jevđenić, S., Grgić, Ž., Bugarski, D., Maljković, M., 2007. Infectious abortion in sheep. *Biotechnology in Animal Husbandry*. 23 (5-6), 383 - 389
- Wang, C.R., Qiu, J.H., Gao, J.F., Liu, L.M., Wang, C., Liu, Q., Yan, C., and Zhu, X.Q., 2011. Seroprevalence of *Toxoplasma gondii* infection in sheep and goats in northeastern China. *Small Ruminant Research*. 97:130–133. <https://doi.org/10.1016/j.smallrumres.2011.02.009>.
- Weiss, L.M., and Dubey J.P., 2009. Toxoplasmosis: A history of clinical observations, *International Journal of Parasitology*. 39 (8) 895–901, <https://doi.org/10.1016/j.ijpara.2009.02.004>

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.