

SERO-SURVEILLANCE OF “PESTE DES PETITS RUMINANTS” PPR IN LEBANON

C. Hilan, L. Daccache, K. Khazaal, T. Beaino¹, E. Massoud¹ and F. Louis

Lebanese Agricultural Research Institute, P.O. Box 90-1965, Fanar, Lebanon

¹ Saint Esprit University, Faculty of Agricultural Sciences, Kaslik, P.O. Box 449, Jounieh, Lebanon

fanarlab@lari.gov.lb

(Received 11 November 2004 - Accepted 5 October 2005)

ABSTRACT

“Peste des Petits Ruminants” (PPR) is one of the most dangerous viral diseases affecting small ruminants leading to high mortality among non-vaccinated animals (25% of newly born sheep and goats). The purpose of the study is to carry out sero surveillance for the detection of the incidence of the disease. PPR is caused by a Morbillivirus genus, Paramyxoviridae family. A competitive Elisa “specific” test was performed on non-vaccinated by PPR vaccine 2205 goat and 1300 sheep blood sera. Results showed the presence of PPR virus antibodies in 52% of individual goat, 62.5% of goat flocks and 81% of goat in mixed flocks; and 61.5%, 75.8% and 73.8 % in sheep individuals and flocks respectively. The Bekaa and South Lebanon are the most infected. On the other hand 979 cow blood sera were tested to detect the presence of PPR virus antibodies. The results showed that 5.72% of the cows was positive, mainly in the Bekaa (9.5%) and 13.45% of the cattle farms spread in different regions of the country. Yearly calves’ sera were free of PPR antibodies. A newly developed vaccine by CIRAD/ FRANCE and manufactured by JOVAC/ JORDAN was used for the purpose of controlling the development of immunity rates in vaccinated small ruminants. During 9 months of study, imported and local sheep and goats sera (968) were tested before and after vaccination. Results showed that age, gender, and management did not show any differences in antibody titers. Goats seem to have better immune response than sheep. Local goats showed better immune response compared to imported breeds. It is therefore recommended to conduct a mass vaccination campaign covering the whole flock of small ruminants in order to limit economical losses caused by the disease.

Keywords: ovine, caprine, humoral immunity, Peste des Petits Ruminants, sero-surveillance, vaccination

INTRODUCTION

“Peste des Petits Ruminants” PPR is an acute, highly contagious and frequently fatal viral disease leading to a mortality rate entailing grave economical losses amongst small ruminants. It is caused by a virus belonging to the Morbillivirus Genus, Paramyxoviridae family (Bourdin et Laurent, 1967). In the last ten years, Lebanon did witness some “eruptions” of this disease where PPR has been clinically diagnosed in the Bekaa & South Lebanon districts namely in Hermel, Baalbeck, Tyre and Saida regions. In fact, the disease

has been suspected following its characteristic syndrome including pyrexia, ocular, nasal & mouth discharges, oral erosions, conjunctivitis, pneumonia, diarrhea and rapid death in small ruminants (Daubney, 1991). Also, lesions caused by this disease (zebra stripes all along gastro-intestinal tract and congested mesenteric lymph nodes) have been highly indicative in this prospect (Lefevre, 1987). However, the etiology of the disease was confirmed as relevant to PPR after conducting ELISA test on diseased animal sera. The disease is wide spread in West Asia and North Africa countries (Roeder, 1999), and actually, it is suspected that some 25% of the deaths in newborn caprine and ovine are caused by PPR infections (Zyskowski, 1996), (FAO/IAEA, 1994). The presence of this virus in asymptomatic carriers such as the cattle population, which were tested with the Rinderpest (RP) competitive ELISA, and found negative, and especially about the presence of centers of infection of both ovine and caprine populations in the different Lebanese regions should be investigated. (Crowther, 1996).

The goal of the present study is to determine the incidence of the PPR disease in Lebanese large and small ruminants' herds leading to the total eradication of its devastating effects on the Lebanese rural economy. The objective of this study consists on conducting PPR c-ELISA tests (Anderson *et al.*, 1991) on the available sera of cattle and small ruminants (Libeau *et al.*, 1991) in order to detect the PPR antibodies, determine the incidence of the disease, mapping of the virus presence and detecting the centers of infection. Thus, contain this disease and prevent any outbreaks by establishing whether a vaccination campaign may be imperative or not. For the purpose of controlling the evolution of immunity rates in small ruminants flocks, a newly developed vaccine by CIRAD (Centre de Coopération Internationale de la Recherche Agronomique pour le Développement) – France manufactured by JOVAC (Jordan Bio-Industries Center) – Jordan, was used. This vaccine had proven its efficiency in different parts of the Middle – East where PPR cases were reported such as Jordan, UAE, Kuwait, Qatar, Bahrain, Oman and Afghanistan (IAEA, 1999).

MATERIAL AND METHODS

The aim of the sero-surveillance was not only to collect blood randomly from the animals but also to conduct investigations on the diseases encountered in the field and on the management practices of each farmer. For this effect, farmers filled up a data sheet during the process of blood collection. Furthermore, Lebanon was considered as a single stratum after taking into consideration the tightness of the Lebanese total area and the big displacements effected by herds between the different seasons of the year. The sample size was computed using the epi-info software provided by the joint FAO/ IAEA division. It was determined with a 95 % confidence level. This is based on the following formula:

Sample size = $n / [1 - (n / \text{population size})]$, according to Kish and Leslie. Whereby:

n: Uncorrected Sample Size = $Z^2 [P(1-P)] / D^2$

Z: the Standard Normal Deviate corresponding to the required Confidence level.

P: Expected Frequency

D: Deviation between P and Worst Acceptable Frequency

The needed samples for the surveillance were 1529 and 1532 sheep and goat blood samples respectively leading to a total of 3061. The surveying teams succeeded not only in covering all Lebanese departments but also provided more samples than it was originally requested, 3505 instead of 3061. As a result, an increased confidence level of around 97%

was reached.

A judicious scheme was designed to allow proper execution of sero-surveillance on Small Ruminants (Allen, 1995). The latest statistics on small ruminants show that their total population is estimated around 815746 heads (321726 ovine, 494020 caprine). The repartition of the animals by departments is as follow: Bekaa (68%, 45%), Mount Lebanon (5%, 13%), North Lebanon (18%, 18%), South Lebanon (9%, 24%) for ovine and caprine respectively (Ministry of Agriculture, 1997). The size of the local cattle population at the time of the survey was reaching a number of 77000 heads distributed as follows: 19 % in Mount Lebanon, 29 % in South Lebanon, 30% in the Bekaa Valley and 22% in North Lebanon (Ministry of Agriculture, 1995) (Hilan C. 1995). The adopted strategy for blood sampling was based on Dr Allen's recommendations (Allen, 1995) requesting a series of steps and resulting in the determination of 15 cattle heads per farm from, at least, 200 farms all over Lebanon. This adopted strategy would then insure a complete randomization in the blood sampling method. A special questionnaire form was prepared. Consequently, the same Epi.Info software specifically designed by the joint FAO/IAEA division was enabled to derive the minimum sample size required at the present field conditions at 95 % confidence level. At the end of the blood collection phase, a total of 979 blood samples, representing 238 cattle farms from a total number of 138 Lebanese villages, were tested for the presence of PPR virus antibodies (Table 4). All the blood samples taken were divided into 3 aged groups in order to determine the susceptibility of young cattle to the virus of PPR: less than one year (150), between 1 and 2 years (111) and more than 2 years (718) (Hilan *et al.*, 1997).

A Photometer type Lab system BDSL Immunoskan PLUS with integrated optical filters of 405 - 450 and 492 nm HTR and its accessories was used for testing PPR antibodies by competitive Elisa Kits (manufactured by Pirbright Laboratory – UK).

On the other hand, a study regarding the post vaccination immunity rate has been conducted adopting a detailed scheme. The selection of the flocks had to respond to various criteria affecting the immunity rates against PPR, namely breeding density, cohabitation of sheep and goats, origin of breeds, location and altitude. The following 3 flocks reflecting the above criteria were chosen:

1. An extensively bred flock of Baladi local Goats at Zabbougha – Mount Lebanon.
2. An intensively bred flock of both Baladi and Chami (imported) goat breeds in cohabitation with the Awassi breed (local) of Sheep at Terbol – Bekaa.
3. An intensively bred flock of Chami goats in cohabitation with the Awassi sheep at Mejdlaya – Zgharta – North Lebanon.

Primarily, a sero-surveillance was conducted including some 476 individuals selected randomly of the above flocks and which met the above criteria. Each individual was tested for detecting the presence of the anti-PPR antibodies in its serum using the c-ELISA technique. Then, from each of the 3 above flocks a sample flock was retained which individuals were meeting the following sub-criteria specifically:

- For goats: the origin: Baladi (local) and Chami (imported) - the gender: male and female - the age: adult and young (less than 6 months of age) - the immunity status: half of the individuals immune against PPR & half non-immune.

- For sheep: the gender: male and female- the immunity status: half of the individuals immune against PPR & half non-immune. Hence, the age criterion was dismissed in sheep since most of the animals had passed their young age status. The females in the flocks were nearly all in their last stage of gestation.

The next step consisted on vaccinating half of the selected individual of the above 3 sampled flocks, whereas half of them presented antibodies and the remaining lacking these. On vaccination day, all the flock samples individuals were sampled for blood prior to the vaccination in order to determine their exact state of immunity at that time. All the vaccination conditions have been taken into consideration in order to prevent erratic results. Blood sampling had to be reiterated on the same individuals on days 15, 90 and 270- post vaccination day to probe the changes occurring on the immunity status of the flocks. The cumulated numbers of ELISA tests reached 968 detailed as follows: 476 tests following the initial sero-surveillance and 492 tests (4 x 123 tests performed on 37 from sheep and 86 from goat) following the sampling on day zero, 15, 90 and 270 from vaccination day. The evolution of the immunity rate in goat and sheep prior and following vaccination of half of the individuals was then studied.

RESULTS

Collected data from the field and test results are detailed in the following 2 tables. In the first table immunity status of flocks are presented whereas in the second table immunity status of individuals is given. As evident from Table 1, flocks are divided among three groups: the first consists of mixed sheep and goats, the second of sheep exclusively and the third of goats exclusively.

Except for South Lebanon, immunity rates of goats flocks are greater than of sheep in mixed flocks.

This fact is also evident in referring to overall immunity rates (73.8% for sheep and 81.0% for goats). 100% of Bekaa mixed flocks have most of their animals immune against PPR. Following are South Lebanon flocks with their entire sheep portion immune against 80% of their Goat portion. Mount Lebanon flocks immunity lies in the end with 42.9% and 57.1% of their respective sheep and goats' portions are immune. However, in comparing immunity rates in separate sheep and goat flocks, these are found in conflict with the above with 75.8% and 62.5% for sheep and goats respectively. Moreover, all departmental sheep flocks immunity rates lay in a range of 66.7% to 100% compared to a range of 48.3% to 80.6% for goats, a fact that confirms a very high immunity rate in sheep population. The predominance of the sheep immunity rate in comparison to that of the goats is once more confirmed in referring to the individual immunity.

An overall immunity rate in sheep in the study areas was 61.5 % while the rate in goats was 52.0% (Table 2). Except for Mount Lebanon where the rate in sheep and goats was 39.0 and 46.3% respectively. In South Lebanon and the Bekaa, the rates were 78.0% in sheep and 63.4% in goats.

TABLE 1

Immunity Rates against PPR in Regional Small Ruminants Flocks

Region	District	Mixed Flocks					Sheep Flocks			Goat Flocks		
		No ·	No.Sheep		No.Goat		No.	Post	Rate	No.	Post	Rate
			Post	Rate	Post	Rate						
North	Akkar	0	0	0.0	0	0.0	4	2	50.0	0	0	0.0
	Danieh	6	3	50.0	6	100	3	2	66.7	17	8	47.1
	Zgharta	3	2	66.7	1	33.3	1	1	100	4	2	50.0
	Bcharre	0	0	0.0	0	0.0	0	0	0.0	1	1	100
	Batroun	2	0	0.0	1	50.0	1	1	100	5	2	40.0
	Koura	3	2	66.7	2	66.7	0	0	0.0	2	1	50.0
Partial Total		14	7	50.0	10	71.4	9	6	66.7	29	14	48.3
Bekaa	Hermel	3	3	100	3	100	0	0	0.00	0	0	0.0
	Baalbeck	9	9	100	9	100	4	1	25.0	4	1	25.0
	Rachia	2	2	100	2	100	2	2	100	4	3	75.0
	Zahle	2	2	100	2	100	3	3	100	1	1	100
Partial Total		16	16	100	16	100	9	6	66.7	9	5	55.6
South Leb.	Saida	2	2	100	1	50.0	2	2	100	11	9	81.8
	Tyre	0	0	0.0	0	0.0	6	6	100	9	8	88.9
	Nabatieh	3	3	100	3	100	1	1	100	9	6	66.7
	Jezzine	0	0	0.0	0	0.0	0	0	0.0	2	2	100
Partial Total		5	5	100	4	80.0	9	9	100	31	25	80.6
Mount Leb.	Chouf	4	2	50.0	3	75.0	0	0	0.0	3	3	100
	Aley	0	0	0.0	0	0.0	0	0	0.0	3	2	66.7
	Metn	1	1	100	1	100	5	4	80.0	9	8	88.9
	Baabda	0	0	0.0	0	0.0	1	0	0.0	1	0	0.0
	Kesrwan	0	0	0.0	0	0.0	0	0	0.0	8	0	0.0
	Jbeil	2	0	0.0	0	0.0	0	0	0.0	3	3	100
Partial Total		7	3	42.9	4	57.1	6	4	66.7	27	16	59.3
Grand Total		42	31	73.8	34	81.0	33	25	75.8	96	60	62.5
Total Number of Sampled Flocks		171										

The results of PPR Antibody Rate in Cattle Sera are shown in Table 3. It shows that an overall 5.72% of the tested cattle population had immunity against PPR. Furthermore, the Bekaa Valley had the highest rate with 9.5 % of positively tested sera (nearly the double of all other districts). The rates in all other 3 districts were approximately equal, ranging between 4.32% and 5% in South Lebanon and Mount Lebanon respectively.

TABLE 2
Immunity Rates Against PPR in Sampled Small Ruminants

Department	Caza	Sampled Sheeps	Positive Sheep		Sampled Goats	Positive Goat	
			No.	Rate		No.	Rate
North Leb.	Akkar	123	50	40.7	0	0	0.00
	Danie	154	70	45.5	340	122	35.9
	Zgharta	70	42	60.0	148	40	27.0
	Bcharre	0	0	0.00	20	11	55.0
	Batroun	38	6	15.8	116	41	35.3
	Koura	40	17	0.0	76	27	35.5
Partial Total		425	185	43.5	700	241	34.4
Bekaa	Hermel	63	53	84.1	46	31	67.4
	Baalbeck	212	172	81.1	161	97	60.2
	Rachia	55	27	49.1	75	41	54.7
	Zahle	114	86	75.4	40	35	87.5
Partial Total		444	338	76.1	322	204	63.4
South Leb.	Saida	71	50	70.4	251	197	78.5
	Tyre	91	77	84.6	203	131	64.5
	Nabatieh	63	49	77.8	206	131	63.6
	Jezzine	52	40	76.9	0	0	0.00
Partial Total		277	216	78.0	660	459	69.5
Mount Leb.	Chouf	36	17	47.2	113	66	58.4
	Aley	0	0	0.00	54	35	64.8
	Metn	93	42	45.2	127	98	77.2
	Baabda	5	1	20.0	43	6	14.0
	Keserwan	0	0	0.00	101	0	0.00
	Jbeil	20	0	0.0	85	37	43.5
Partial Total		154	60	39.0	523	242	46.3
Total		1300	799	61.5	2205	1146	52.0
Total Number of Sampled Animals			3505				

The presence of immune animals in surveyed farms shows the dissemination of the disease on the Lebanese territories. Table 4 reveals the presence of immune cattle in all the farms surveyed where some 13.45% of the total tested cattle farms showed immunity against PPR.

TABLE 3**Distribution of Immune Cattle with Respect to Age Groups on Lebanese Districts**

District	Age Group	No. of Tested Animals	No. of Positive Animals	Rate of Positive Animals %
Bekaa	< 1 Year	40	0	0.00
	1-2 Years	37	3	8.11
	> 2 Years	144	18	12.50
Partial Total		221	21	9.50
North Leb.	< 1 Year	1	0	0.00
	1-2 Years	4	1	25.00
	> 2 Years	109	4	3.67
Partial Total		114	5	4.38
Mount Leb.	< 1 Year	74	2	2.70
	1-2 Years	35	2	5.71
	> 2 Years	211	12	5.69
Partial Total		320	16	5.00
South Leb.	< 1 Year	35	0	0.00
	1-2 Years	35	1	2.86
	> 2 Years	254	13	5.12
Partial Total		324	14	4.32
Grand Total		979	56	5.72

As shown in Table 4, North Lebanon district presented the highest number of covered farms (100) from 55 villages, as opposed to South Lebanon farms (15 farms from 11 villages). In Mount Lebanon and Bekaa Valley the number of surveyed farms were 34 and 89 farms from 26 and 46 villages, respectively.

Regarding the third part of the study that is the evolution of post vaccination immunity rate, the results of the initial sero-surveillance of 476 sheep and goat selected randomly from the 3 flocks responding to various criteria affecting the immunity rate are detailed in Table5. This table is more explicit in numbers using the location criteria.

From Table 5, and comparing the rates of immune sheep & goats to the previous sero-surveillance results, it is noted that still the rate in sheep is higher than goat with 50.68% and 44.71% respectively (compared to 61.5% and 52.87% in the sero-surveillance).

Goats pilot survey results:

* Results of Pilot PPR sero surveys on days 0, 15, 90 and 270 in different breeds of

sheep, taking into consideration pre-vaccination, vaccination and time are given in Table 6.

TABLE 4

Distribution of Villages and Farms with Immune Cattle in the Lebanese Regions

District	Regions	Sampled Villages	No. Tested Farms	No. Farms with Immune Animals	Rate: Farms with Immune Animals %
Bekaa	Baalbeck	8	12	3	25.00
	Rachia	25	54	4	7.41
	Zahle	6	6	1	16.67
	W. Bekaa	4	4	1	25.00
	Hermel	3	13	3	23.08
	Total	46	89	12	13.48
North Leb.	Akkar	33	52	1	1.92
	Tripoli	15	33	2	6.06
	Koura	5	9	1	11.11
	Zgharta	2	6	1	16.67
	Total	55	100	4	4.00
Mount Leb.	Jbeil	4	6	0	0.00
	Keserwan	3	3	0	0.00
	Metn	5	6	2	33.33
	Chouf	9	10	2	20.00
	Aley	4	8	4	50.00
	Baabda	1	1	0	0.00
	Total	26	34	8	23.53
South Leb.	Saida	7	9	5	55.55
	Tyre	2	3	2	66.66
	Nabatieh	2	3	1	33.33
	Total	11	15	8	53.33
Grand Total	138	238	32	13.45	

TABLE 5

Initial Sero-Surveillance Results Using the Location Criteria

Region	Sheep			Goats		
	Sampled	Positive	Rate	Sampled	Positive	Rate
Zabbougha	Nil	Nil	Nil	49	0	0
Mejdlaya	91	91	100	70	70	100
Terbol	130	21	16.15	136	44	32.35
TOTAL	221	112	50.68	255	114	44.71

TABLE 6

Mean of Antibody Titers in Baladi & Chami Goat Breeds

Vaccination Status	Baladi Breed				Chami Breed			
	Day 0 (%)	Day 15 (%)	Day 90 (%)	Day 270 (%)	Day 0 (%)	Day 15 (%)	Day 90 (%)	Day 270 (%)
(+)/vac.	74.50	82.00	85.00	88.66	82.63	66.75	82.20	83.50
(+)/n.vac.	72.25	77.75	80.66	84.00	84.00	68.33	80.00	78.17
(-)/vac.	13.90	74.41	75.90	78.52	8.17	71.21	71.75	78.10
(-)/n.vac.	15.24	21.22	17.78	21.30	11.35	12.50	14.70	16.83

The non-vaccinated results in both immune (+) and non immune (-) statuses constitute a “Blank reading” for the vaccinated ones thus crystallizing the “environmental” factors that surround the animal. While studying the development of the antibody titers in immune Baladi and Chami goats, it can be noted how extremely close are the readings of Blanks in both species (72.25% - 84%) to their respective vaccinated fellows (74.5% - 82.63%), reflecting that the variations are many due to environmental causes. The vaccinated individuals proved the efficiency of the PESTEVAC in raising the antibody titers from around 13.9% and 8.17% to 74.41% and 71.21 % respectively in both Baladi and Chami which readings were always very close with a slight advantage for the Baladi by 4% which was absorbed at the end.

Concerning the gender criteria, the following Fig. 1 will compare between the results of non immune and vaccinated male and female individuals belonging to the local breed Baladi to determine whether this criteria has any significant impact on the antibody titer.

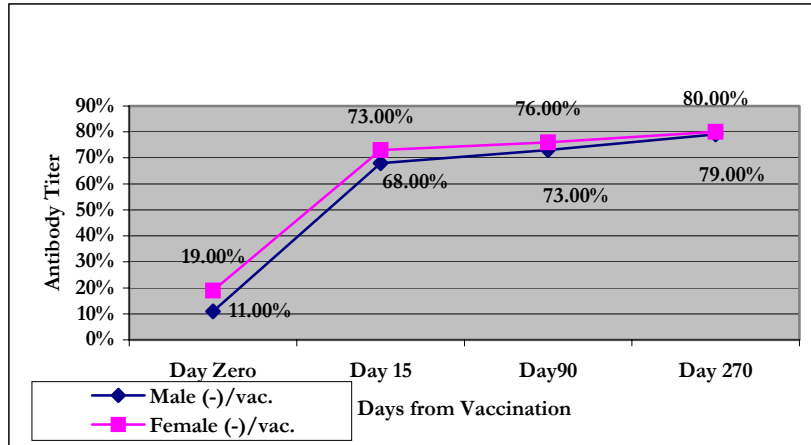


Figure 1. Non immune & vaccinated Baladi goats: the gender criteria.

From this figure, a significant difference of 8% is noted in favor of the female gender at the early stage where no vaccination was involved. This gap is desorbed along the way and at the end following the vaccination process to reach 1% leading to the conclusion that the vaccine does not induce major different responses where gender is considered.

* Concerning the age criteria, the goats were divided between two categories of individuals where as young (less than 6 months of age) and adult individuals were considered also belonging to the local Baladi breed. Fig. 2 will direct the light on the antibody development issue from: 11% and 15% to 80% and 80.5%.

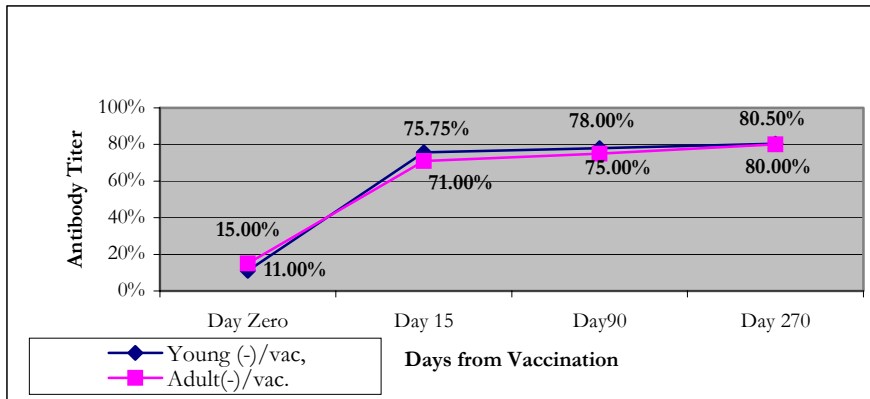


Figure 2. Non immune & vaccinated Baladi goats: the age criteria.

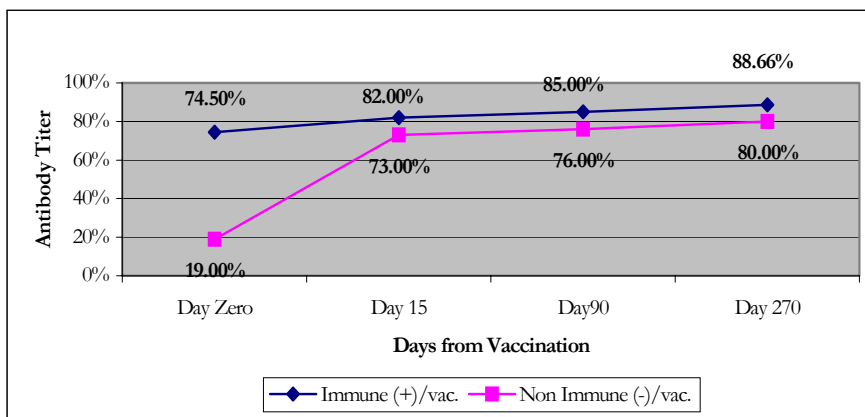


Figure 3. Vaccinated Baladi goats: the immunity status criteria.

* Concerning the immunity status criteria, goats were divided between vaccinated immune and vaccinated non immune individuals all from local Baladi Breed. The results are shown in Figure 3.

From this figure, it is clearly shown that the immunity background of an individual affects its post vaccination antibody titers at all stages where the advantage for the originally immune subject is by approximately 9% at all times.

* Concerning the farming system criteria goats in this category are divided among intensively and extensively bred non immune vaccinated individuals belonging to the Baladi breed.

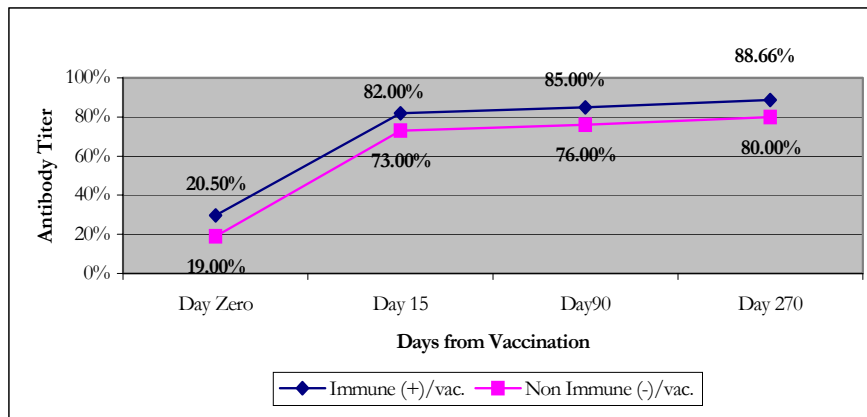


Figure 4. Vaccinated non immune Baladi goats: the farming system criteria.

From this Fig. 4, it is shown that the farming system does not influence the final antibody titer in either category since both have witnessed very close readings along the pilot survey path. Although, it is quite expected that antibody titers in intensively bred flocks grow constantly whereas in extensively bred ones they reach a plateau as early as day 15 (77%-79%). Also the small advantage in favor of intensively bred flocks was foreseeable, especially with their individuals exchanging the PPR Virus antigens to a greater extent.

Sheep pilot survey results:

Gender has no effect on post-vaccination antibody titer (Figure 5).

Though females, as in the previous case, have a slightly better immune response than males difference of 7% (Day 90, 71% to 64%), the gap is narrowed at the final stage to reach less than 2%.

* Concerning the immunity status criteria, the following Table 7 details the antibody titers of the sampled sheep following their immunity and vaccination states.

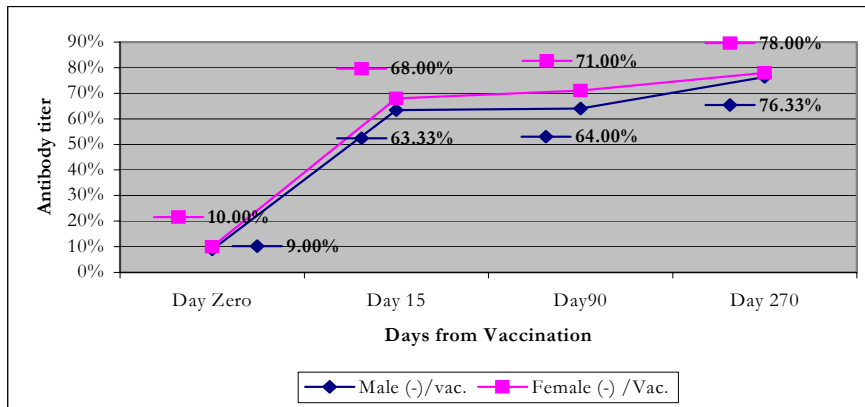


Figure 5. Non immune vaccinated sheep: the gender criteria.

TABLE 7

Antibody Titers in Sampled Awassi Sheep

Correlation Immune Status/ Vaccination	Day 0 (%)	Day 15 (%)	Day 90 (%)	Day 270 (%)
(+)/vac.	85.11	64.75	71.66	70.33
(+)/n.vac.	84.50	72.75	73.45	70.29
(-)/vac.	9.50	65.66	67.50	77.17
(-)/n.vac.	7.30	9.25	10.00	14.50

To better illustrate the above results, each original immunity status must be looked upon separately. As far as the non – immune individuals status is considered, the blank reading standing for the non-vaccinated individuals have witnessed a small increase (from 7.30% to 14.50%) due to environmental causes, as was the case in goats. In the opposite, the antibody titers in vaccinated individuals increased drastically from 9.50% to reach at day 270 a peak of 77.17% indicating that the vaccine worked perfectly. As far as the immune individual’s status is considered, it is remarked that the antibody titers in both blank readings and vaccinated ones have decrease from approximately 85% to reach 70% on day 270 prior to vaccination. It is deduced that the vaccination did not induce this drop since reading at day zero gave similar result.

There was a sharp decrease in antibody titer after 15 days post vaccination,

probably due to the vaccination stress. This drop was soon to be fixed as the antibody titers reached approximately the same levels on day 90 and were quite equal on day 270. The effect of vaccination on sheep's antibody titers has been also studied. It is concluded that both individuals from immune and non immune backgrounds will end up enjoying a titer of antibodies ranging between 70% and 77%. As noted previously, the vaccine was not totally responsible for diminishing the antibody titer in originally immune individuals.

DISCUSSION

Following the above results, it is now ascertained that heavy casualties among small ruminants' flocks in the previous years were due to PPR disease. As a matter of fact, in North Lebanon and the Bekaa valley high immunity rates coincided with these PPR outbreaks. Furthermore, it is determined that the disease is endemic to Lebanese small ruminant flocks specially after consulting the high rates of immunity which reached up to 78.0% and engulfed all Lebanese departments. In comparison, both North and Mount Lebanon are presenting relatively low immunity (nearly half of that found in the South and the Bekaa) with rates ranging between 34.4% and 46.3%, due to extremely extensive breeding. Hence, it is very important to note that no PPR vaccination has been applied prior to the conduct of the serosurveillance.

After consulting the obtained immunity rates, it may be concluded that sheep are more immune than goat population. Shepherders are inclined to raise the local Awassi breed specially that it is very resistant to diseases, well adapted to temperature fluctuations and has good productivity of meat, wool and milk. Goat breeders prefer to replace the local goat breed with the Chami that presents finer genetic quality thus producing more meat and milk. As a matter of fact, this Chami breed presents high susceptibility to PPR virus. For this reason, goat population is more subject to contracting this disease leading to massive death whereas in sheep population this disease would be asymptomatic or would appear in its mildest forms.

The observed antibodies to PPR in cattle sera may be due to contacts with PPR infected small ruminants. Vaccination with PPR is ruled out since the vaccine is not used for cattle in Lebanon. It is worth mentioning that there is a large transhumance of herds across international borders, mainly Syria, where PPR is largely endemic. Another reason for the presence of antibodies in cattle sera is infection with PPR virus: nearly all districts present a certain rate of immune cattle. The most illustrative Cazas are Zahle in the Bekaa and Aley in Mount Lebanon where 13.63% and 14.81% of their tested cattle respectively were immune.

*The Bekaa region showed the highest overall correlation between tested animals showing PPR antibodies and sampled farms containing immune animals 9.5% (Table 3) and 13.48% (Table 4) respectively.

*In Hermel Caza, where there have been previously reports of deaths of small ruminants due to clinically diagnosed PPR, there is a correlation between immune tested cattle 10.53% (Table 3) and farms with immune cattle 23.08% (Table 4).

*In Baalbeck, 12.5% immune cattle rate was present in 25% of the visited farms.

*In the highly suspected areas of Bekaa and South Lebanon districts, the rate of immunity in less than one year of age cattle is very low (Table 3) due to lack of contacts with the virus in the present intensive rearing system.

Regarding the evolution of post vaccination immunity rate, it is well noted that first the high rate of PPR immune animals (both Sheep and Goats) in Mejdlaya is remarkable indicating that the disease is endemic in the country especially with no previous specific vaccination history. Second the overall immunity rates in both Baladi and Chami are almost in the same range in the various readings. The small changes in antibody titers in this category reflects a change in the environment status of the animals such as the overall health condition of the flocks during this period, the variation in seasons... Moreover, the antibody titer in the Baladi breed maintained a constant increase and ended up significantly higher (more than 5%) than the Chami breed though the opposite was the case at the beginning of the pilot surveys. This fact confirms once more, that the local breed is more adapted to the local environmental variations. The non vaccinated animals in both Baladi & Chami did show an increase in their titers due to environmental reasons. Nonetheless, Baladi breed proves once more to have a slightly better immune response (88%) than the Chami breed (80%). Goats seem to have a better response to the vaccine than sheep, with antibody titer reaching 77% approximately at its peak.

After reviewing the titers' development with all its variations, the vaccine seems not to be affected by age. Young individuals present at some periods a higher titer, which could be justified by the maternal immunity that is enhanced at low age, and is reabsorbed as time goes by.

Upon comparing the sheep and goat pilot survey results, it is shown that PESTEVAC vaccine leads to equal antibody titers in both originally non immune individuals whereas the readings at day 270 are respectively 78.5%, 78.1% and 77.17% in Baladi, Shami goats and Awassi sheep. Besides the vaccine has no effect at all on either goats or sheep antibody titers in which variations are mainly due to environmental causes especially previous asymptomatic infections. It does not cause any decrease in antibody titers. While looking at figures 1 to 5, it is obvious that both vaccinated male and female Baladi goats and Awassi sheep present at the end similar titers with respectively 80% and 78% for female and 79% and 77.17% for males. Females in both species, present an insignificant increase by approximately 1% compared to males.

It is worth mentioning that the vaccine does not affect the antibody titers in both imported and local breeds. On the contrary, it might increase, though insignificantly, titers. Sheep seem to have better adaptability to this disease than goats where the outbreaks are likely to occur recurrently.

CONCLUSION

The "Peste des Petits Ruminants" PPR is an endemic disease among the Lebanese small ruminants herds. 61.5% of sheep and 52.0% of goat populations are immune. It is mostly prevalent in South Lebanon and the Bekaa valley due to intensive breeding while it is less prevalent in North and Mount Lebanon due to the extensive breeding. Local Awassi sheep breed presents an innate resistance against PPR while newly introduced Chami goat breeds are highly susceptible. The presence of PPR virus has been ascertained in Lebanese cattle (5.72%) by the fact that specific anti PPR antibodies have been found in the sera of cattle that constitute asymptomatic carriers of the virus. Cattle in Lebanon seem to be protected against rinderpest virus by both PPR (5.72%) and Rinderpest immunity (21.6%)

(Sero-surveillance on Lebanese Cattle, RAW/5/004, 1996), knowing that immunity against one virus entails necessarily immunity against the other due to their antigenic interactions. PPR virus is present in all Lebanese cattle flocks but at different proportions; the Bekaa district is the mostly affected. Following the vaccination by PESTEVAC anti PPR vaccine, it has been noted that the PPR antibody titers have increased drastically in both sheep and goats thus ensuring protection in case of any eventual contamination. Local goats (Baladi) show a better immune response compared to imported breeds (Chami) with approximately 88% and 80% antibody titers respectively. Goats seem to have a better response to the vaccine than sheep with antibody titer reaching 77% approximately at its peak. This vaccine does not affect the antibody titers originating from acquired or natural immunity. Moreover, age, gender and breeding densities fail to create great divergences in the antibody titers resulting from vaccination. Finally, based on the above findings and knowing that 39.53% and 47.13% of the Lebanese goat and sheep flocks do not have any protection against PPR outbreak, it is strongly recommended to conduct a mass vaccination campaign covering the whole flock of small ruminants. This would constitute a major step towards control this highly endemic disease effectively.

REFERENCES

- Allen, J.D. 1995. *End of mission report on provision of epidemiological support for Rinderpest surveillance in Lebanon*. IAEA Division of Technical Cooperation Programmes, pp. 12-17.
- Anderson, J., McKay, J.A. & Butcher, R.N. 1991. The use of monoclonal antibodies in competitive ELISA for the detection of antibodies to Rinderpest and Peste des Petits Ruminants viruses, Panel Proceedings IAEA-SM-318. *International Symposium on Nuclear and Related Techniques in Animal Production and Health*, Vienna, Austria.
- Bourdin, P. et Laurent Vautier, A. 1967. Note sur la structure du virus de la peste des petits ruminants. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*, 20: 383-386.
- Crowther, J. 1996. *Report on the second workshop for the model regional project*. RAW/5/004. IAEA/FAO.
- Daubney, R. 1951. *Personal notes on Rinderpest*. FAO Veterinary Division.
- FAO/IAEA. 1994. *Establishment of external quality assurance procedures for use with FAO/IAEA ELISA kits*. FAO/IAEA Animal Production & Health Section, pp. 2-7.
- Hilan, C. 1995. Agricultural research strategy. *Animal Production*, pp. 63-64.
- Hilan, C., Ousayran, N., Daccache, L. & Louis, F. 1997. *Sero-surveillance of Rinderpest in Lebanon*. Thesis Lebanese University, Faculty of Agriculture.
- IAEA 1999. Recommended procedures for diseases and serological surveillance as part of the global rinderpest eradication program (Grep). FAO/IAEA, *Tec. et Doc.*, 747: 7-8.
- Lefèvre, P.C. 1987. Peste des Petits Ruminants et infection bovipestique des ovins et caprins. *Etude et synthèse de l'ITEMVT*, 5, 99pp.
- Libeau, G., Diallo, A., Calvez, D. and Lefevre, P.C. 1991. A competitive ELISA using anti-N monoclonal antibodies for specific detection of Rinderpest antibodies in cattle and small ruminants. Panel Proceeding IAEA-SM-318. *International Symposium on Nuclear and Related Techniques in Animal Production and Health*, Vienna, Austria.
- Ministry of Agriculture. 1995, 1997. *Annual Reports*.

- Roeder, P. 1999. *Software on PPR & Rinderpest- Differential diagnosis*. FAO.
- Zyskowski, W. 1996. *Support for Rinderpest surveillance as a regional model project in West Asia*. (RAW /5 /004). IAEA.