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CAPRIPOX IN THE YEMEN ARAB REPUBLIC AND THE SULTANATE OF OMAN

R. P. KITCHING, J. J. MCGRANE[1] and W. P. TAYLOR

Animal Virus Research Institute, Pirbright, Surrey GU24 0NF, UK

SUMMARY

Capripox was shown to be endemic in all the provinces of the Yemen Arab Republic and the Sultanate of Oman. Investigations into outbreaks of capripox indicated that some strains of capripoxvirus were infecting both sheep and goats and this was confirmed by inoculating experimental sheep and goats with isolates derived from field cases. The husbandry methods prevalent in the Middle East predispose to the rapid spread of capripox and annual vaccination of all sheep and goats must be considered as the only effective method of controlling the disease.

INTRODUCTION

Capripox contributes a significant addition to the disease burden of the sheep and goats in the Yemen Arab Republic (YAR) and Sultanate of Oman (Oman). However, little is known about the distribution and prevalence of capripox in those countries. In the sheep and goat rearing areas of Dhamar and the coast (Tihamas) in the YAR major outbreaks occur annually although infected flocks can be found throughout the year. Clinical capripox has not been reported in the northern province of Saadah. In the northern provinces of Oman capripox also occurs in major outbreaks but there are no descriptions of disease from the southern province of Salalah.

This paper describes an investigation to determine the distribution of sheep and goats in the YAR and Oman with antibodies against capripoxvirus and relates this to the reported distribution of disease outbreaks. The host specificity of strains of capripoxvirus was studied by inoculating isolates recovered from infected sheep and goats in the YAR and Oman into experimental animals. The results of these investigations, together with an assessment of the husbandry methods prevalent in the YAR and Oman, are discussed in terms of the epidemiology of capripox.

MATERIALS AND METHODS

Serum was collected from sheep and goats at markets and from individual flocks. Locally bred animals with no history of capripox vaccination were sampled; the age of these animals was estimated from their dentition (Sisson, 1953).

Disease investigations

In Oman 14 outbreaks of capripox were investigated clinically in May 1984. Virus isolation was attempted using nasal swabs and skin lesions collected from 30 locally bred goats and five locally bred sheep with signs of capripox; two animals were slaughtered and a post-mortem examination carried out. In YAR outbreaks of capripox were routinely investigated by the staff of the veterinary services project. Between February 1983 and April 1985, 49 outbreaks of capripox were

[1] c/o ODA, Eland House, Stag Place, London SW1E 5DH, UK.

visited and samples of skin biopsy or post-mortem material from infected animals together with a history of the outbreak were submitted to AVRI Pirbright. A standard questionnaire was completed on each outbreak.

Tissue samples were ground with sterile sand in a small volume of Glasgow modified Eagle's medium (GMEM) with antibiotics as previously described (Kitching and Taylor, 1985). The suspensions were centrifuged at 600 g for 5 min and the supernatant adsorbed on to monolayers of secondary lamb testis (LT) cells for 1 h in 25 cm^2 plastic tissue culture vessels. The monolayers were washed once with fresh medium and 10 ml of GMEM with 2% ox serum and antibiotics added. The cultures were examined daily for evidence of cytopathic effect.

Small pieces of tissue were also homogenised in an equal volume of sterile phosphate buffered saline (PBS). The suspension was then stained on electron microscope grids with phosphotungstic acid pH 7·2 and examined in a transmission electron microscope.

The neutralisation index (NI) of the sera collected in the YAR in October 1984 was determined against the Kenya 0240 isolate using the method described by Precausta, Kato and Vellut (1979). All the sera were examined by agar gel immunodiffusion (AGID) against [^{35}S] radio-labelled antigen prepared from a Nigeria sheep isolate of capripox using the method described by Kitching, Hammond and Black (1986). Positive sera gave a radio-labelled precipitation line that formed a line of identity with control positive sera in the adjacent well.

Experimental animals

The identity and virulence of three of the virus isolates were tested by experimental animal inoculation:

Yemen goat isolate Four adult British white goats, two Dorset Horn cross sheep four months old and two adult Border Leicester cross sheep were inoculated with $\log_{10}$ 4·3 $TCID_{50}$ of capripoxvirus isolated from the lung of a three month old goat.

Oman sheep isolate One adult British white goat and one adult Border Leicester cross sheep were inoculated with $\log_{10}$ 3·5 $TCID_{50}$ of capripoxvirus isolated from a skin papule collected from an infected adult sheep.

Oman goat isolate One adult British white goat and one adult Border Leicester cross sheep were inoculated with $\log_{10}$ 3·2 $TCID_{50}$ of capripoxvirus isolated from skin collected at post-mortem from a three month old goat. Inoculations were by intradermal injection of 0·2 ml of the virus isolate in GMEM into a clipped area on the flank. The experimental animals were housed in high security isolation boxes; they were examined daily and rectal temperatures recorded. A separate box was used for each experiment.

RESULTS

Forty-nine outbreaks of suspected capripox in the YAR were confirmed by electron microscopy and isolation of capripoxvirus in tissue culture. Twenty of these outbreaks were in mixed herds of sheep and goats and in eight of these capripox was diagnosed in both sheep and goats. In seven of the remaining 12 outbreaks in mixed herds only sheep were reported infected and in five only goats were reported infected. Twenty-two outbreaks affected sheep in flocks consisting only of sheep and 7 outbreaks affected goats in herds consisting only of goats. The distribution of the outbreaks reflected to a certain extent the distribution of the veterinary field officers (VOs). Eighteen were in the province of Hodeidah

(two VOs), 20 were in the province of Sana'a (two VOs), nine were in the province of Dhamar (two VOs), one in the province of Hajjah (one VO) and one in the province of Ibb (no permanent VO). However, there were no reported outbreaks in Saadah where a field officer was also present. Field officers were not based in the remaining provinces of YAR.

Veterinary field officers investigating the outbreak were never able to obtain answers as to the probable source of the infection. In some cases, when outbreaks occurred close to earlier outbreaks, it was assumed that infection had spread within the neighbourhood. Analysing the response to questionnaires it is possible to draw a number of conclusions about the outbreaks in YAR viz.:

1. In most of the outbreaks only animals below one year old showed clinical signs.
2. The majority of the outbreaks were reported in the provinces of Sana'a, Hodeidah and Dhamar. These three provinces support over 60% of the total sheep and goat population of the YAR.
3. In the province of Dhamar, where the density of sheep is high and the grazing areas of different villages tend to overlap, disease spread quickly from one village to another.
4. There was no obvious seasonal incidence of capripox although the major outbreaks in Dhamar were in February and March of each year investigated.
5. The majority of outbreaks of clinical disease were in either sheep or goats. Only eight outbreaks (five in Hodeidah) were reported as affecting sheep and goats.
6. Abortion was associated with only one outbreak and goats were involved.
7. A range of clinical signs from death to very mild disease was reported.
8. Usually less than 10% of the flock was affected with clinical signs; however, five outbreaks were reported in which 70% of the flock was affected of all age groups.
9. Clinical disease was seen in the Hodeidah quarantine station.

In Oman four of the 14 outbreaks of capripox investigated involved sheep and goats and one affected sheep only. However, over 80% of the small ruminant population in Oman are goats and this could bias the impression of host preference. Clinical cases of capripox were found in all the northern provinces of Oman but there were no reports of clinical capripox in the southern province of Salalah. In the majority of the outbreaks investigated in Oman only the young animals were affected. However, in four outbreaks involving goats the morbidity approached 100% with clinical signs ranging from severe to mild. The mortality was below 10% except in Musandam where the outbreak coincided with the introduction of peste des petits ruminants (PPR). Here the mortality was between 50% and 90%.

In the YAR and Oman it was clear that many cases of capripox were unreported owing to the difficulty of communication away from the main roads and the small number of veterinary staff available to monitor disease outbreaks,

The clinical signs of generalised capripox in field outbreaks were similar in the sheep and goats and can be described together. The infected animal was depressed with a rectal temperature between 40°C and 41·5°C. Hard intradermal papules between 1 and 2 cm in diameter were present over the face and body, particularly noticeable on the ears and on the hairless region under the tail and in the groin and axilla. Frequently these papules coalesced to form larger swellings. The superficial lymph nodes, particularly the prescapular, were grossly enlarged.

The eyes were almost totally closed because of swelling of the upper eyelids. Rhinitis was usually severe completely blocking the nares with mucus and, in the later stages of the disease, mucopurulent material. The papules below the nares and on the lips were ulcerated. The skin covering the papules became necrotic and could be rubbed off, particularly on the face, sometimes releasing a small quantity of fluid and leaving a raw granulating area. The papules with or without the necrotic cap still present became scabs which remained on the body for three to four weeks. Animals that had recovered from moderate or severe infections could be identified by the presence of scars on the face and under the tail.

The results of post-mortem examination of field cases of sheep and goats that had died of capripox were also similar. The bodies were dehydrated and emaciated. Death usually occurred before the papules had become necrotic and some animals had secondary myiasis of the eyes and nares. In all cases papules were found in the lungs and in the abomasal mucosa and frequently also on the tongue, pharynx, turbinate mucosa and kidney. The internal and superficial lymph nodes were enlarged and oedematous. Evidence of severe abomasal and intestinal parasitism and bacterial pneumonia was also found in some of the carcases.

Eighty-three of the 84 serum samples (99%) from the YAR which had a NI titre greater than $\log_{10}$ 1·0 were also positive on AGID. Positive AGID sheep and goat serum samples were found from all the provinces of Oman and the YAR indicating the presence of capripox in areas such as Salalah in Oman and Saadah in the YAR where clinical cases had not previously been reported. However, there were farms on which there was evidence of only a very low prevalence or complete absence of infection. In Oman and the YAR the percentage of animals with capripox antibodies was higher in the older age groups (Tables I and II).

Experimental animals

Yemen goat isolate The four sheep and two goats inoculated with the Yemen goat isolate all developed a pyrexia of over 40°C and generalised infection. The two goats and two lambs died; the results of the post-mortem examination on these animals has been described previously (Kitching and Taylor, 1985). The two older sheep recovered.

Oman sheep isolate The sheep and the goat inoculated with the Oman sheep isolate developed a pyrexia by day 5 post-inoculation (pi), followed two days later by secondary papules over the body, together with rhinitis and conjunctivitis. The goat died on day 12 pi. The sheep had a pyrexia until day 18 pi, by which time the papules had become necrotic without vesicle formation.

Oman goat isolate The sheep and goat inoculated with the Oman goat isolate

TABLE I

Age distribution of AGID-positive sheep and goats in YAR

Age (months)	Sheep			Goats		
	Number examined	Number positive	%	Number examined	Number positive	%
3–18	52	23	44	28	14	50
18–30	13	9	69	8	6	75
30–42	13	12	92	8	8	100
>42	101	70	69	58	41	71

TABLE II

Age distribution of AGID-positive sheep and goats in Oman

Age (months)	Sheep Number examined	Sheep Number positive	Sheep %	Goats Number examined	Goats Number positive	Goats %
3–18	110	28	25	204	75	37
18–30	14	5	36	74	28	38
30–42	6	1	17	28	12	43
>42	61	28	46	181	128	71

developed a pyrexia on day 7 and day 6 pi respectively. No secondary papules were seen on the sheep and its temperature returned to normal by day 13 pi. The goat developed generalised infection and died on day 10 pi. The post-mortem appearance of the two goats that died was similar to that described previously (Kitching and Taylor, 1985).

Animal husbandry

The sheep and goats of the YAR are either home-bred or imported from Somalia, Sudan, Eritrea or Kenya. The majority of the imported animals enter the YAR through the ports of Al Hodeidah and Mukha. They are usually taken without quarantine restrictions directly for slaughter or to be sold in the suqs (markets) of Al Hodeidah, Taizz, Ibb and Sana'a. Occasionally they are seen in the suqs of the Tihama and smaller inland towns particularly immediately prior to a religious festival or "id". Imported animals command a lower price than locally produced animals and are generally considered inferior in taste.

In the suqs the imported animals are usually kept separate from the local animals although this is not an invariable rule. Animals may be bought and sold a number of times by dealers and be taken to more than one suq. Eventually they will be sold and taken back to a village where they will be slaughtered. However, considerable time may elapse before they are required in which they will be kept in some degree of contact with the village animals. They may even be incorporated into an existing flock or, in the case of a Yemeni returning from Saudi Arabia with the intention of remaining in the village, form the basis of an entire flock.

Within the village each family will usually have a flock of between 10 and 50 animals. These flocks will be a mixture of sheep and goats although in some areas such as Dhamar they may be entirely sheep. During the day each herd is taken out to graze but as they return to the village in the evening they will frequently mix. In the colder central highlands the herds are separately housed, usually within a room of the owner's house, whereas on the coastal plain each herd is kept in a corral. When housed the animals are usually kept in very crowded conditions and the ventilation is invariably inadequate. Epidemiologically the animals of a single village can be regarded as a single group, In the more mountainous regions of the interior and in the drier regions of the Tihama village groups tend not to mix. However, on the plains of the central plateaux flocks from one village may share pasture or a watering hole with flocks from neighbouring villages.

Most towns have a suq at which local animals are traded or sold and within the suq there is considerable mixing of animals. It is not uncommon to see sick

animals for sale as it is considered prudent to dispose of these animals before they become a total loss. Usually they are sold for immediate slaughter but opportunity will exist for them to disseminate their infections.

Sheep and goats are also kept in the towns and cities. Here, however, they may be kept entirely within the confines of the owner's house and garden or allowed to forage through the streets during the day and brought into the house at night. Those allowed out will mix with other flocks and thus form the equivalent of a village group. Those kept restricted will also remain isolated from the prevalent diseases.

When fodder becomes expensive animals from the cities are moved out into the villages sometimes a considerable distance away. Similarly if drought is affecting one area of the YAR whole village groups will be taken by truck to areas where pasture is still available. Therefore ample opportunity exists for the dissemination of infectious disease among the sheep and goats of YAR. With regard to sheep and goat pox there is a sufficient population of sheep and goats within YAR to maintain the disease within the country but it is probable that there is frequent introduction of new strains of disease from eastern Africa. The spread of disease tended to follow the direction of the wadis which provide the main thoroughfare from the Tihama to the central plateaux 2,000 m above sea level. However, some areas on the mountain slopes of the plateaux are extremely difficult to reach and will remain effectively isolated.

The husbandry methods in Oman are similar to those described in the YAR. However, regular importation of sheep and goats is restricted to Merino sheep from Australia. These enter without quarantine whereas animals imported from Africa, India or the Middle East are kept in strict quarantine for three weeks. Sheep and goats can enter the province of Musandam directly from the United Arab Emirates or Iran and the outbreak of PPR and capripox undoubtedly originated from one or both of these countries. There was also evidence that animals taken illegally from the United Arab Emirates into the northern Batinah of Oman initiated outbreaks of capripox. From here capripox spread down the coast and then entered the interior through the mountain gap at Bid Bid. The long incubation period for capripox and the greatly improved road system in Oman allowed the movement of animals incubating the disease over long distances. As in the YAR motorised traders moved animals from one market to another until they were sold. The considerably higher value of sheep and goats in Oman relative to their value in Africa and the United Arab Emirates encouraged attempts to by-pass the import regulations.

DISCUSSION

Clinical, epidemiological and serological evidence indicated that capripoxvirus was present throughout Oman, Musandam and the YAR. The age distribution of animals with antibodies against capripoxvirus suggested that capripox was not always present but occurred in outbreaks when there was a sufficiently large susceptible population. The majority of the older animals had antibodies and would have experienced a number of previous contacts with the disease whereas many of the younger animals had not been previously infected.

More than one strain of capripoxvirus was present in the YAR and Oman. Some of these had a host preference, causing clinical disease in either sheep or

goats in mixed flocks while some strains were clinically infecting both sheep and goats. In Saadah (YAR) and Salalah (Oman) milder strains were circulating which were not causing clinically recognisable disease in sheep or goats.

The results of the animal inoculation experiments showed that the three isolates tested produced clinical disease in British sheep and goats irrespective of whether they were originally isolated from a sheep or goat. This was consistent with the field data which suggested that in some outbreaks the same strain was causing clinical infection in both sheep and goats. The results also indicated that sheep could be mildly infected with strains of capripoxvirus which would become very virulent if transmitted to goats. Thus, in some of the field outbreaks investigated involving goats, sheep could also have been infected but not shown recognisable clinical signs. The importance of breed susceptibility to capripoxvirus could not be assessed, and might significantly influence the appearance of clinical signs and conclusions concerning the host preference of the strains of capripoxvirus in the YAR and Oman.

The serological tests which detect antibody to capripoxvirus are not entirely satisfactory. Animals which have recovered from severe infection with contagious pustular dermatitis (CPD) develop antibody which produces a line of identity with antibody against capripoxvirus in AGID (Kitching *et al.*, 1986). Thus possibly as many as 10% of the AGID positive samples (Kitching, unpub.) were due to the presence of CPD antibody. It is not known how long detectable AGID antibodies against capripoxvirus persist in recovered animals. Previous work (Kitching *et al.*, 1986) indicated that they could persist a year although this depended on the severity of infection. Many animals with no detectable AGID antibodies may nevertheless be immune to capripox as the cell mediated immune response—of major importance in immunity to pox disease—persists longer than the persistence of detectable antibodies (Kitching *et al.*, 1986). Eighty-three of the 84 serum samples with a N1 greater than $\log_{10}$ 1·0 were also positive on the AGID test. But this test also would only detect animals that had experienced a severe capripox infection and would probably not identify the majority of the capripox immune animals.

Farms were found in Oman in which none of the animals had detectable antibodies to capripoxvirus. The complete absence of capripoxvirus antibodies in all age groups indicated that those animals would be highly susceptable to infection with capripox. The history of five outbreaks in the YAR and four outbreaks in Oman in which animals of all age groups were affected confirmed that communities existed in which capripox had not been present for three to four years and a large susceptible population had become established. Work by Kitching and Taylor (1985) which showed the complete cross resistance between strains of capripoxvirus would imply that such outbreaks were not due to the introduction of antigenically novel strains of virus.

The husbandary methods prevalent in the YAR and Oman predisposed to the transmission of capripox. However, the rate of spread of disease within groups of animals was not consistent. In Oman disease was seen to spread through flocks of 3,000 animals within a month whereas it could take three months to infect all the animals in a flock of 12. The important determining factors in the speed of transmission from infected to susceptible animals were not ascertained. The presence of skin abrasions which allowed the entry of pox virus was proabably important and thus the co-infection with PPR which occurred in Musandam

would have predisposed to the rapid transmission of capripox. The feeding of goats on abrasive foliage and the presence of biting arthropods was probably also important in the rate of spread of disease.

Capripox was an economically significant disease in the YAR and Oman causing death and lowered production in animals already subject to nutritional deficiency and chronic diseases such as parasitism. It could be anticipated that any attempts to intensify sheep and goat production or to upgrade the indigenous breeds would result in severe outbreaks of capripox.

It would be difficult to control capripox in the YAR or in Oman by prohibiting the importation of animals from infected areas as there would always be the possibility that infected animals would be imported illegally. Also the size of the small ruminant population in these countries is probably sufficient to maintain existing strains without the necessity of importing new strains. Annual vaccination of all sheep and goats must be considered as the only effective way of controlling capripox in the YAR and Oman.

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CAPRIPOX EN REPUBLIQUE ARABE DU YEMEN ET DANS LE SULTANAT D'OMAN

Résumé—On a montré que l'infection Capripox est endémique dans toutes les provinces de la République Arabe et du Sultanat d'Oman. Des recherches conduites dans des foyers de capripox ont montré que quelques souches de virus capripox étaient infectieuses pour les moutons et les chèvres; ceci a pu être confirmé expérimentalement en inoculant des moutons et des chèvres avec des souches originaires de cas naturels. Les méthodes d'élevage existant au Moyen-Orient favorisent la dissémination rapide du capripox; la vaccination annuelle doit être considérée comme étant la seule méthode effective de contrôle de la maladie.

CAPRIPOX EN LA REPUBLICA ARABE DE YEMEN Y EL SULTANATO DE OMAN

Resumen—Se comprobó que el capripox era endémico en todas las provincias de la República Arabe de Yemen y en el Sultanato de Oman. Las investigaciones de los brotes ocurridos, dieron como resultado el aislamiento de una cepa de virus capripox entre otras, capaz de infectar ovejas y cabras. Lo anterior se comprobó mediante la inoculación experimental. El sistema de manejo en el Este Medio favorece la rápida difusión de la enfermedad, siendo la vacunación anual de todo el efectivo, el único método efectivo para controlar la enfermedad.