Distribution and biology of *Ornithodoros erraticus* in parts of Spain affected by African swine fever

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***Ornithodoros erraticus* was found in 30·7 per cent, 35·0 per cent and 71·0 per cent of the pig-pens sampled in the provinces of Salamanca, Badajoz and Huelva in which African swine fever is a problem in the rearing of Iberian pigs. Between 38 and 65 per cent of the pig-pens in these areas are now abandoned and their populations of *O erraticus* are extinct or becoming so because they can no longer feed on pigs, which in Spain are their main hosts. The abandonment of pig-pens has resulted in the elimination of most soft ticks infected with the virus of African swine fever, and means that the distribution of ticks is now irregular and focal. Another factor affecting their distribution is the kind of soil on which the pig-pens are located. In abandoned pig-pens, the adults and large nymphs survive for about five years or longer when animals occasionally enter them. Hungry tick populations may transmit African swine fever when feeding in winter, whereas the populations that have continuous access to pigs do not feed until the pig-pens reach a temperature of 13 to 15°C. In the latter populations, each stage exhibits a single annual peak of activity, which implies that the development from larva to adult takes two to three years. Pigs may die as a result of the bites, but on no occasion were 100 per cent of the fasting ticks seen to feed, even though they had the opportunity of doing so. This may hinder the eradication of this soft tick from infested pig-pens.**

THE measures adopted in Spain for eradicating African swine fever have focused mainly on the elimination of reservoirs and vectors of the virus. Pigs may act as reservoirs of the virus, as may the soft tick *Ornithodoros erraticus*, which is the European vector of the virus (Sánchez Botija 1963, 1982; Wilkinson 1984).

Currently, the advances made in the diagnosis of African swine fever are making it possible to eliminate the pigs that are carriers of the virus, although it is clear that the efficacy of such measures will be limited unless they are accompanied by the eradication of the populations of *O erraticus*, which can maintain and transmit the virus experimentally for at least 300 days (Endris and others 1987). This soft tick has been reported in many provinces in Spain (Cordero del Campillo and others 1980) (Fig 1A) in relation to relapsing fever in humans, but nothing is known of the biology, ecology and the current status of its populations in the natural environment.

The aim of the present work was to gather basic data on these aspects of the biology of *O erraticus* to provide essential information for controlling the tick populations infesting pig-pens and also to gain a better understanding of the epizootiology of African swine fever.

Of the provinces in which *O erraticus* has been reported, Salamanca, Badajoz and Huelva were selected for study, because they have the largest number of farms rearing free-range Iberian pigs and are therefore those most affected by African swine fever. From their very beginning, such farms have been intimately associated with holm-oak (*Quercus ilex rotundifolia*) type savannah, one of the most characteristic habitats of the south-western part of Spain. African swine fever has become enzootic in this habitat because the extent of free-range pig husbandry facilitates contact between pigs and sources of the virus such as *O erraticus* in rural pig-pens. Other possible causes have been discussed by Sánchez Botija (1982).

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Material and methods

Sampling

The presence of *O erraticus* on pig farms was determined by searching the soil removed from all kinds of cracks and fissures inside 260 pig-pens and also from the burrows of small mammals found on the pasture frequented by the pigs. Other likely habitats, which had never been occupied by pigs but were near to infested pig premises, were also searched, to find out whether the vectors were able to exist by parasitising other hosts. The earth was removed mechanically using test tube brushes of different sizes.

The type of construction, the time since the buildings were used by pigs, and whether African swine fever had been recorded on the premises were recorded. This information was provided by the farmers or official bodies involved in the disease control programme.

Seasonal dynamics

To gain insight into the seasonal dynamics of the populations of *O erraticus* one or two pigs (25 to 35 kg) were left for 24 hours once a month from January until December in a pig-pen measuring 2×1·5×1 m, in Salamanca province that was infested by *O erraticus* and had previously always housed pigs, except during the three months before the experiment; during this year no other animals entered the buildings. Immediately before introducing the animals and immediately after they were removed, samples of the surface soil were collected from the floor and from cracks in the walls. The number of bites received by the pigs, and the temperature and relative humidity of the pig-pen during the experiment, were recorded. External temperatures were provided by the meteorological station closest to the pig-pen.

Isolation of specimens from the samples

The contents of the samples were examined by placing them under a 100 w lamp on a white dish (diameter, 30 cm) so that, on attempting to escape, the specimens would fall into a plastic bag sealed on to the end of a funnel.

Measurements

The following information was recorded: the population density (number of specimens/100 to 1000 g of earth); the specimens that had fed, according to their macroscopic appearance; the percentage of mated females, by microscopic observation of their genitalia; and the developmental phases, classifying the nymphs according to their body length. The body lengths of each stage were established by measuring 100 specimens of each, obtained from female ticks collected on

TABLE 1: Prevalence of *Ornithodoros erraticus* in occupied and unoccupied pig pens in the provinces of Salamanca, Badajoz and Huelva

	Pig-Pens examined (% of adult ticks in soil) II With pigs continuously or periodically	Without pigs continuously for 1-5 years	6-10 years	>10 years	Total
With *O erraticus* total examined (%)					
Salamanca	32/76 (42·1)	6/36 (16·7)	2*/6 (33·3)	3*/35 (8·6)	43/153 (28·1)
Badajoz	16/47 (34)	2/16 (12·5)	2‡/8 (25)	1/5* (20)	21/76† (27·6)
Huelva	7/11 (63·6)	8/13 (61)	–	7§/7 (100)	22/31 (71)
Number of African swine fever affected pig-pens among those containing *O erraticus* (%)					
Salamanca	8 (25)	6 (100)	1 (50)	3 (100)	
Badajoz	14 (87·5)	2 (100)	2 (100)	1 (100)	
Huelva	7 (100)	7 (87·5)	–	6 (85·7)	

* Rabbit burrows were observed in these pig-pens
† Of the 76 pig-pens, 16 were simply circular walls of stones; if these are not considered the prevalence was 35·0%
‡ Only remains of dead specimens were found
§ Two of these pig-pens contained only dead specimens; in the other five there were both live ticks and rabbit burrows
II With swine continuously or periodically, 11·4 ± 2·0, without swine continuously for one to five years, 61·8 ± 5·2, without swine continuously for six to 10 years, 83·3; the last figure is based on the analysis of a single sample

the farm and kept in a chamber maintained at 28°C, and with a relative humidity of 85 to 90 per cent. Their mean, and maximum and minimum lengths, in mm were as follows: N1 1·06 (0·95 to 1·20), N2 1·64 (1·45 to 1·90), N3 1·99 (1·70 to 2·35), N4 2·7 (2·20 to 3·10). Some of these lengths are different from those reported by Fernández Garcia (1970); this discrepancy may have been due partly to the fact that this author only measured five specimens from each stage and partly to the variations shown by *O erraticus* in body size (Hoogstraal and others 1954).

Results

Prevalence and habitats

Of the 260 pig-pens examined, 208 were old buildings constructed of stone or clay bricks (Fig 2A,B) with numerous cracks in the floors, roofs and walls. Table 1 shows how many of the 260 pens contained *O erraticus*, according to whether they were in current use or had been abandoned. Considering all the pig-pens, 71·0 per cent of those in Huelva were infested, and 30·7 per cent of those in Salamanca and 27·6 per cent of those in Badajoz. However, in Badajoz, if one considers only the typical pig-pens, excluding 16 that did not have a roof and which were all negative, 35·0 per cent of the pig-pens were infested. Of the 52 modern pig-pens examined, all of which were situated on the range, six were constructed next to or on the site occupied by old pig-pens and harboured soft ticks in the few cracks observed in their cement structure.

O erraticus was also found in 28 burrows of small mammals (Fig 2C) and in hollows in the boles of holm-oaks, in both cases at a distance of less than 300 m from heavily infested pig-pens, in areas where the pigs were likely to rest. However, no burrows were found on many farms in the areas frequented by the pigs and it is therefore not possible to conclude that this is the maximum distance that *O erraticus* can migrate from the buildings. No soft ticks were found in 50 burrows situated in places where there had never been pigs or in sites with pig-pens in which there had been no pigs for several years. From the infested burrows, only one to 12 specimens were isolated, either fed or fasting according to whether there were pigs in the area at the time of sampling. An exception was rabbit burrows, with entrances in the pig-pens themselves or the immediate vicinity; some contained many specimens, some of them fed, although it was not possible to discover whether they had fed on rabbits or pigs.

Survival

More infested pig-pens were found among those continuously or periodically occupied by pigs but it was still pos-

TABLE 2: Seasonal prevalence and feeding activity of *Ornithodoros erraticus* and environmental conditions in one pig pen in Salamanca Province. Also given are the mean monthly temperatures in the provinces of Salamanca, Badajoz and Huelva

Month	January	February	March	April	May	June	July	August start	August end	September	October	November	December
Number of animals introduced into pen 1	1	1	1	1	1	5 1 dead	1	1	2	2	1	1	1
Number of bites on pigs	10	5	159	$2·6 cm^2$	†	4 †	†	dead	2 †	2 †	$2·4/cm^2$	5	36
Estimated number of ticks/kg of soil from:													
Floor	40	15	9	25	460	490	1790	440	*	*	230	*	8
Fissures	*	*	*	*	750	2150	716	3020	2820	2910	1110	1010	550
Relative humidity inside pig-pen	97	88	90	84	90	85	80	60	55	85	95	95	98
Mean temperature inside pig-pen (°C)	10·0	8·8	11·0	15·0	15·0	16·5	21·0	22·5	23·0	21·5	13·0	4·5	8·0
Mean temperature outside pig-pen (°C)	8·7	8·2	10·1	13·0	13·0	14·8	17·9	19·9	19·9	16·8	9·9	4·8	13·5
Mean monthly temperature in Salamanca (°C)	2·9	5·7	9·2	11·4	13·6	18·4	21·0	22·1		20·5	11·4	7·7	6·2
Mean monthly temperature in Badajoz (°C)	8·6	9·8	11·7	13·5	17·0	22·1	25·9	25·5		22·6	17·4	12·2	9·1
Mean monthly temperature in Huelva (°C)	9·4	10·2	11·8	14·5	18·0	22·2	26·1	26·0		23·0	17·9	13·1	9·7

* Samples were not taken because it was considered that the number of specimens in them may have been altered by the presence of damp soil in fissures (hindering extraction), or the presence in soil of specimens hidden by fallen rocks, etc
† Uncountable number of bites

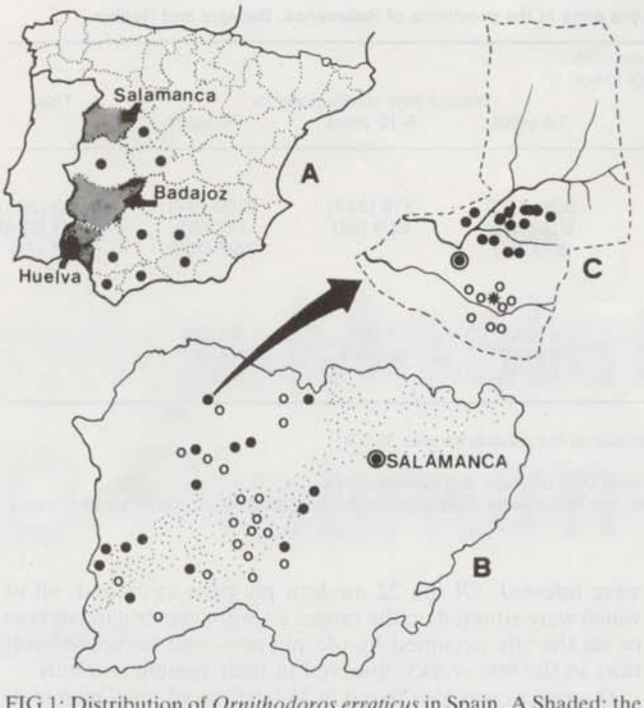

FIG 1: Distribution of *Ornithodoros erraticus* in Spain. A Shaded: the provinces studied; dotted, provinces in which the vector has been cited. B Province of Salamanca; municipalities examined in which *O erraticus* was present (●) or absent (○); dotted: soils derived from conglomerates and sand or sandstones. C Diagram of a village in Salamanca province showing the current distribution of pig-pens infested with *O erraticus* (●), uninfested (○) or in which only some live/dead specimens were found (*)

sible to find numerous live ticks in pig-pens that had been unoccupied for more than five years consecutively. Some pig-pens had been abandoned as long ago as the 1960s, when African swine fever first entered Spain, and in these only dead specimens were found in the pig-pens that had been closed. Where small numbers of live specimens were found there were also rabbit burrows and other animals may also have entered the buildings and acted as hosts for the soft ticks.

In pig-pens without either pigs or rabbits, no fed specimens of ticks were observed among the several thousand that were examined, and neither larvae nor first-stage nymphs were observed, whereas in the occupied pig-pens the developmental stages were predominant (Table 1).

Buildings with African swine fever and O erraticus

In Huelva and Badajoz, pig-pens on the same premises whether infested with *O erraticus* or free of the vector, had been affected by African swine fever either during the sampling year or during previous years. However, in Salamanca, pigs in 75 per cent of the pig-pens containing *O erraticus* had never been affected. The situation in abandoned pig-pens is very different; all of them are known to have been affected by African swine fever, generally on numerous occasions, which led to their being abandoned by the owners. At present it is not known whether these pens had been concurrently infested with *O erraticus* and it is impossible to find out because they have been closed for periods far longer than the soft ticks can survive under conditions of total fasting. However, the fact that most of these abandoned pig-pens are arranged in groups (Fig 1C) and that live specimens of ticks or the remains of dead ones were found in some of them suggest that they had been infested in previous years.

Distribution

In Salamanca *O erraticus* was found in 45·7 per cent of the villages keeping free-range pigs, and there was no geographical separation between the villages in which the vector was present or absent (Fig 1B). However, *O erraticus* was absent from a group of villages which were located on soils derived from conglomerates and sandstone. In these villages 56 pig-pens were examined that were identical to those in other villages located on granites, quartzites or micacites.

In Badajoz and Huelva, *O erraticus* was present in practically all the villages visited, although, as in Salamanca, their presence in one pig-pen did not necessarily mean that all the pig-pens in the area were infested. Thus, on 34·6 per cent of the farms with more than one pig-pen only some of them were infested (Fig 1C).

Seasonal dynamics

The pigs placed in pen 1 (Table 1, Fig 2D-H) were bitten relatively seldom from November to March (between five and 159 times) but very frequently in spring and towards the end of summer. During the summer the numbers of ticks feeding were so great that they killed the pigs in less than 24 hours. In the months during which the pigs died additional pigs were introduced into the pen to enable the unfed ticks in the population of *O erraticus* to feed. These extra pigs did not die despite the bites they received. No further attempt to feed all the ticks was made after it was observed that the introduction of one new pig on each of five consecutive days resulted in only a small decrease in the unfed population, from 48·5 per cent on the first day to 39 per cent on the fifth. All the pigs that died showed extensive subcutaneous haemorrhages and considerable hypertrophy of peripheral lymph nodes (Fig 2 I).

Table 2 shows the population density and the environmental conditions recorded in the pen during the 24 hour period of observation in each monthly trial. From December to April the population remained static, with only eight to 40 ticks being found per kg of surface soil. From May onwards, the population abandoned the deepest parts of the cracks until up to 1790 ticks/kg were found in the surface soil.

During the period of tick activity, all the developmental phases were found in the soil samples, and biting the pigs. However, each developmental phase had its own period of activity, as was shown not only by the larger numbers in the surface soil of the test pig-pen but also in the percentage of soft ticks that had apparently fed (Fig 3).

According to the field observations, it was sometimes possible to find recently fed ticks in pig-pens that had not been occupied by pigs during the year, except for a few days in December to January. Since the activity of ticks in the pen was practically nil during these months, the previous observation suggests a different kind of behaviour in the populations, depending on whether the ticks had fed or not during the year. To discover whether these differences were real, a pig was enclosed for 24 hours in December in the first pen (T_{max} 11°C, T_{min} 5°C) and another in a similar pig-pen (pen 2) that had been closed for 15 months, 2 m away. In the first pig-pen there were eight ticks/kg in the soil and the pig was bitten 36 times; in the second there were 225 ticks/kg and the bites were uncountable.

Discussion

It may be assumed that until the introduction of African swine fever into Spain in 1960, the prevalence of *O erraticus* in pig pens in the provinces of Salamanca, Badajoz and Huelva must have been very high, and probably similar to the current situation (42 to 64 per cent) in those pens that have been occupied by pigs, either continuously or periodically, since that time.

As may be seen in Table 1, 38 to 65 per cent of the pig-pens traditionally devoted to pig rearing are currently abandoned and hence their populations of *O erraticus* are either extinct or in the process of extinction. Accordingly, the number of pop-

FIG 2: Common types of pig-pens infested with *Ornithodoros erraticus* and the appearance of some of the pigs enclosed in pen 1 for 24 hours.
A Pig-pens constructed of stones and earth (pen 1 and pen 2). B Pig-pen with a wooden roof and no cement in interior. C Infested burrow 100 m from pen 1 next to a small stream frequented by the pigs. D-H Bites made on the pigs in pen 1: few in winter (D), uncountable during the months of maximum activity, (E,F), pigs killed by large numbers of ticks feeding in summer, (G,H). I Inguinal lymph nodes of one of the pigs that died in pen 1. J Pig on which numerous specimens were still feeding when it was removed from the pig-pen to the field

ulations of *O erraticus* has probably undergone a drastic reduction in recent decades owing to the occurrence of African swine fever, which is the principal cause of the pig-pens being abandoned. However, it is possible that since the 1960s the survival of *O erraticus* has been ensured by the presence, in some pig-pens, of soft ticks which have not been infected with the virus or by the presence of tick populations which were infected with virus of low virulence that allowed farmers to continue their pig-rearing activities. This possibility seems to be corroborated by the situation currently observed in many villages (Fig 1C) in which the only pig-pens inhabited by both *O erraticus* and pigs are those in which no swine have died from African swine fever. It is also corroborated by the high proportions, at least in Salamanca (75 per cent), of tick-infested pig-pens which are still in use and in which African swine fever has not apparently occurred. This is unlike the situation in the unoccupied pig-pens, all of which have been affected by the disease. All the unoccupied pig-pens may also have harboured soft ticks at some time but ticks can now be demonstrated directly in only some of them.

The abandonment of the pig-pens has not only led to the current prevalence of *O erraticus* but may also have deter-

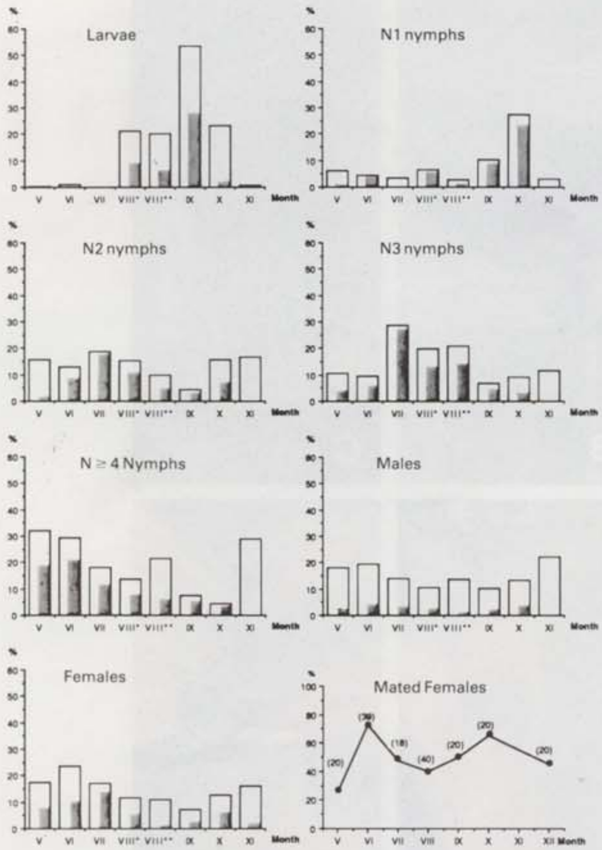

FIG 3: Mean percentages of different developmental stages of *Ornithodoros erraticus* found in the soil of the floor of pen 1 in Salamanca before and after a 24 hour period of occupation by one or several pigs. The percentages corresponding to the month of inactivity are similar to those for November and are therefore not represented, whereas for August the values found at the beginning (*) and the end (**) of the month are given. The black bars indicate the percentage of fed specimens of each developmental stage. The total numbers of females examined are given in brackets

mined the type of irregular and focal distribution shown by the parasite today. However, its irregular distribution might also be due to the nature of the terrain (Fig 1B) as has been reported by Hoogstraal and others (1954) in Egypt.

One factor to be taken into account in the control of African swine fever is the period for which *O erraticus* can survive under conditions of total fasting on premises or land which become devoid of pigs after the appearance of the disease. As seen in Table 1, this period may extend up to five years, because in pig-pens abandoned for longer periods live specimens were only observed in those containing rabbit burrows. The survival period of five years is considerably longer than that observed under laboratory conditions, which was from two to three months up to 1140 days (El Shoura 1987a, b, Fernández-Garcia 1970), probably because in the natural environment the diversity of environmental conditions allows the ticks to choose the most suitable microhabitat, according to their physiological stage (El Ziady 1958).

The longevity of the ticks would explain why in pig-pens infested with *O erraticus* episodes of African swine fever are possible even though the pens have not held pigs for six to 12 months (Sánchez Botija 1963). Furthermore, this longevity of *O erraticus* is presumably what permits it to colonise modern buildings when they are constructed either on or near to old infested buildings. The only cases in which the authors have observed infested new pig-pens have probably been due to the entry of *O erraticus* through fissures appearing in the new cement or from pigs that have previously been housed in old pens.

A striking feature of the Spanish population of *O erraticus*, and hence its importance in the epizootiology of African swine fever, is its dependence on pigs. This is unlike the behaviour of the tick in north Africa where it parasitises small mammals (Colas Belcour 1930, Hoogstraal and others 1954, Khalil and others 1984). Its dependence on pigs also differentiates the tick from others such as *O puertoricensis* which, because it does not depend on pigs, has probably played no part in the epizootiology of the disease in the western hemisphere (Hess and others 1987). The observation of specimens of *O erraticus* in the burrows of small mammals might also suggest that the Iberian populations are able to survive by feeding on hosts other than pigs. The authors believe that this is not the case, because they have never found soft ticks outside pig-rearing enterprises, and the only burrows in which ticks have been found have been in the immediate vicinity of infested pig-pens; they agree with Gil Collado (1953) that the specimens found in holes in the ground away from the buildings have probably fallen off the pigs when they leave the pens; they have seen this happening, particularly when the pigs are herded very quickly (Fig 2J). The spreading of muck from pig-pens onto the fields may also carry the ticks away from the buildings (Gil Collado 1953).

Since *O erraticus* is able to feed on many different animals (Hoogstraal and others 1954) it may be thought that the disappearance of tick populations from inside and outside the pens in the absence of pigs is due to the failure of the ticks to contact other hosts. However, when rabbits enter the pig-pens, some ticks do survive for longer than they would under conditions of total fasting. Nevertheless, it is unlikely that populations of *O erraticus* can survive for very long in this way because rabbits probably enter the pig-pens only sporadically, and because the larvae of *O erraticus* die if they are unable to find a host after a short time (Fig 3). The presence of only adults and large nymphs in abandoned pig-pens containing rabbits indicates that the biological cycle of the tick does not develop normally on these hosts.

The number of bites undergone by the pigs in the first pen and the number of ticks found in the soil imply that the period of tick activity is limited to the months in which the temperature inside the pig-pens reaches or exceeds 13 to 15°C, when the minimum external temperatures are 10 to 13°C. Although *O erraticus* does not undergo any kind of transstadial development until the temperature reaches 18°C (El Shoura 1987b) the fact that many ticks became active at 13 to 15°C and bite pigs suggests that in Salamanca the period of transmission of African swine fever may be between April/May to October, and in Badajoz and Huelva from March/April to November (Table 2).

During the quiescent period most ticks remain hidden in the cracks of the pig-pens, except when there have been no animals in them during the whole year. Under these circumstances, as seen in pen 2, many ticks remain in the surface soil ready to feed on any potential host which comes within range. Although these ticks are immobile in winter they are able to feed, presumably when they are activated by the heat of pigs lying down near them. Consequently, *O erraticus* may also transmit the virus during winter, an important possibility, because in some areas it is only during this season of free range grazing on the holm-oak acorns that the pigs enter the pig-pens.

The length of the biological cycle of *O erraticus* in Salamanca may be as long as two to three years (Fig 3) whereas in Egypt the biological cycle takes only a few months (Khalil and others 1987). The cycle of *O erraticus* in Salamanca was established to be as follows: Larvae → N1 → N2; hibernation; N2 → N3 → N4 and males; hibernation; N4 → N5 and adults of both sexes that would appear at the end of summer, as seems to be shown by the decrease in mated females towards the end of August (Fig 3). The difficulties involved in distinguishing between N4-N5 and young and old adults makes it impossible to establish either the developmental rhythm of these advanced stages or the life span of the adults. The life span, added to the length of the cycle, would provide the maximum period of persistence of the virus of African swine fever in *O erraticus* under the climatic conditions in the study area.

However, a knowledge of the maximum period is of little practical interest because it is unlikely that soft ticks infected with the virus would have a continuous source of pig blood to complete their development, although complete development may have been possible in some cases because of the low mortality rates sometimes observed in pigs with the disease (Hess 1981, Wilkinson 1984). Considering that there would be no pigs in the pig-pens for a period after an outbreak of the disease, the persistence of the virus will be governed by the survival of infected ticks which cannot feed. According to Sánchez-Botija (1982) such ticks may survive for up to eight years, although he did not specify the conditions. However, the authors believe that they would not survive for more than five years, which was the longest period for which tick populations were observed to survive under conditions of total fasting.

It was never possible to find that 100 per cent of the tick population in the first pen had fed, even though they may have had the opportunity to feed (Fig 3). This failure cannot be attributed to the death of some pigs preventing the whole of the population from feeding, because when, in June, five pigs were introduced into the pen only the first pig died, but the proportion of unfed ticks had only fallen by 9 per cent at the end of the five days. The ticks that continue to fast are probably those that have still not overcome the physiological stage of prefeeding (El Shoura 1987a, b) or those that have been unable to feed owing to physical impediments such as obstruction in cracks. The occurrence of these unfed ticks and those which have already fed and retired into the cracks and crevices in the pig-pens may explain why several sprayings with lindane are necessary to eliminate the ticks (Gil-Collado 1953).

In Spain *O erraticus* is important not only as a vector of relapsing fever in humans and African swine fever in pigs but also as a parasite which can kill pigs by their bites. However, such acute deaths are probably uncommon, because the experimental pigs died only when they were introduced individually into pig-pens heavily infested with hungry ticks.

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Identification of the 1/29 Robertsonian translocation chromosome in British Friesian cattle

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Blood samples for cytogenetic analysis were obtained from 23 animals closely related to a pedigree British Friesian bull which was heterozygous for a Robertsonian translocation, and from 35 of its daughters. The aberration was found in one of its relatives and in 19 (54·3 per cent) of its progeny and was identified as the 1/29 Robertsonian translocation by G- and C-banding techniques. It is considered likely that the translocation formed de novo recently.

A ROBERTSONIAN translocation involving chromosomes in cattle was first reported by Gustavsson and Rockborn (1964) in the Swedish red and white breed. The chromosomes involved in the translocation were subsequently identified as numbers one and 29 and consequently the abnormality was referred to as the 1/29 Robertsonian translocation. Gustavsson (1969) demonstrated that the fertility of the daughters of bulls carrying the translocation was significantly lower than that of normal animals, presumably owing to the death of embryos which resulted from the production of unbalanced karyotypes during meiosis. The 1/29 Robertsonian translocation is also recognised in at least 35 other breeds of cattle (Long 1985), and the reported incidence varies between 22·5 per cent in Romagnola cattle to 0·2 per cent in a group of brown Swiss (Long 1985). However, the 1/29 Robertsonian translocation has not until now been identified in the British Friesian breed, although more chromosomes are examined in this country from Friesians than any other breed (Long 1985).

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Materials and methods

The pedigree of an 11-year-old registered British Friesian bull, which was found during routine chromosome analysis to be heterozygous for a Robertsonian translocation involving one of the longest and one of the shortest chromosomes, was traced through the Herd book of the British Friesian Cattle Society of Great Britain and Ireland and any non-registered animal was recorded.

Blood samples for chromosomes analysis were taken from all the relatives of the affected bull belonging to the herd in which it was bred and from all its offspring in the herd to which it currently belonged. Chromosomes from each animal were analysed by the conventional Giemsa stain technique (Moorhead and others 1960) and the translocation was identified by producing G– and C–bands by the techniques origi-