

Genetic resistance to vectors and vector-borne diseases in indigenous West African livestock

Stephen Leak¹, Déthié Faye¹ and Stanny Geerts²

¹ International Trypanotolerance Centre, P.M.B. 14, Banjul, The Gambia, ² Institute for Tropical Medicine. Nationalestraat, Antwerp, Belgium

Introduction

Genetic resistance of some livestock breeds to vectors and vector-borne diseases is a well-known phenomenon. In West Africa, some indigenous breeds of cattle (N'Dama, Baoulé and Muturu) are known to be trypanotolerant and this trait has been characterised in some detail.

Some small ruminant breeds (West African Dwarf Goats [WAD] and Djallon-

knowledge of genetic resistance to vectors and vector-borne diseases in West African indigenous livestock breeds, omitting trypanotolerance in cattle, which has already been well described, and focussing on small ruminants.

Origins and distribution

There is much less information concerning the origins and genetic characterisation of small ruminant breeds in Africa than is

arid Sahelian and savanna zones. The dwarf breeds arose in the Fouta Djallon region of Guinea, as did trypanotolerant N'Dama cattle (Wilson, 1991).

Evolution of genetic resistance

Since dwarf breeds of small ruminants have co-existed in some hot and humid forest environments, with tsetse and ticks since 5000 BC, it is speculated that those breeds would have adapted, through

Ref.	Country	Breed	Control	Expt. design	Trypanosome species	Outcome
1	Togo	Djallonké sheep/goats	'Uninfected' Djallonké	Natural challenge	Predominantly <i>T. vivax</i>	Absence of clinical signs, similar weight gains but lower PCV
2	Burkina Faso	Djallonké sheep and goats	Sahelian sheep and goats	Artificial infection (syringe)	<i>T. vivax</i> and <i>T. congolense</i>	Better control of parasitaemia and clinical signs (PCV). No sig. difference between breeds infected with <i>T. congolense</i>
3	Gambia	Djallonké sheep WAD goats	Uninfected Djallonké and WAD goats	Artificial infection (syringe)	<i>T. congolense</i>	High parasitaemia and drop in PCV but weight gain remained +ve and no mortality
4	Senegal	Djallonké sheep	Sahelian sheep	Artificial infection (syringe)	<i>T. congolense</i> <i>T. vivax</i>	High mortality in Sahelian sheep; no mortality in Djallonké. No breed difference with <i>T. vivax</i> infection
5	Nigeria	WAD	Red Sokoto goats	Artificial infection (syringe)	<i>T. congolense</i>	Positive weight gain and better control of PCV in WAD goats; lower mortality All RS died 11 days post-infection
6	Gambia	Djallonké sheep; WAD	Uninfected WAD and Djallonké	Artificial infection (syringe)	<i>T. congolense</i>	One goat mortality. All animals gained weight
7	Cameroon	Cameroon dwarf goats			<i>T. vivax</i> , <i>T. congolense</i> and <i>T. brucei</i>	Resistance to <i>T. vivax</i> and <i>T. congolense</i> but mortality with <i>T. brucei</i>
8	Gambia	WAD goats	F1 WAD x Sahelian	Artificial infection (syringe)	<i>T. congolense</i>	Higher mortality in F1s. No significant difference in PCV. No significant difference in parasitaemia or weight loss, although there was a tendency to higher parasitaemia and greater weight loss in crossbreds

Table 1.
Summary of studies on trypanotolerance in West African small ruminants.

1 = Mawuena;
2 = Bengaly *et al.*;
3 = Osaer *et al.*;
4 = Touré;
5 = Adah *et al.*;
6 = Goossens *et al.*;
7 = Büngener & Mehlitz;
8 = Faye *et al.*

ké sheep) are also reputedly trypanotolerant (FAO, 1980; Touré *et al.*, 1981; Mawuena, 1986, 1987; Bengaly *et al.*, 1993) as they are able to survive and remain productive in tsetse-infested areas. Although some studies have been conducted to characterise this trait in the past decade, it is less well described as small ruminants have generally received less attention from researchers than cattle. Small ruminants are, nonetheless, of great importance in Africa, particularly for poorer people who are less able to afford or manage cattle. Here, we briefly review

available for cattle. However, it is thought that one of their centres of origin was the Mid/Near east and that they came into Africa through Egypt and the Nile about 5000 BC, as did cattle (Bouchel & Lauvergne, 1996). There are two main groups of goats, the *longipes* (long-legged) and the *brevipes* (short-legged). The *brevipes* are thought to have given rise to the dwarf breeds and to have been the first group to enter Africa. They are predominantly found in the humid, forested areas, coinciding with the distribution of tsetse, whilst the *longipes* are found in the more

natural selection, to the conditions of that environment, as did trypanotolerant cattle. In addition to adaptation to trypanosomosis and tick-borne diseases, they may also have adapted to heat, humidity and to helminth infections. It is therefore suggested that it is important to look not just at trypanotolerance in these breeds, but to their overall adaptation to the West African environment. As small ruminants have a shorter reproductive cycle than bovines, the rate of natural selection might be expected to be faster. However, sheep and goats are generally kept under more

restricted grazing, closer to homesteads than are cattle, and consequently, they are usually exposed to a lower risk of bites from tsetse flies.

Trypanotolerance in small ruminants

Several studies have been conducted to

controlled infection better than Sahelian sheep or maintained productivity at similar levels to non-infected Djallonké sheep.

Goossens *et al.*, (1998) suggested that the mechanism of trypanotolerance is different in small ruminants than in cattle and

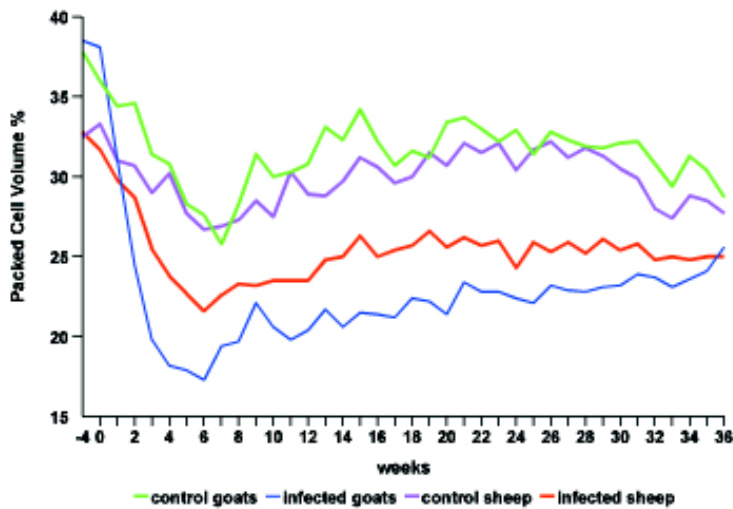


Figure 1. Packed red cell volume (%) in WAD goats and Djallonké sheep infected with *Trypanosoma congolense* compared with uninfected, control groups.

investigate trypanotolerance in small ruminants (Table 1). However, few of these had an experimental design allowing satisfactory comparison between susceptible and tolerant breeds, most being descriptive studies of the effects of artificial or natural trypanosome infections in tolerant breeds or comparative studies of trypanotolerant sheep and goat breeds. Several of those studies indicated that sheep appear to be more trypanotolerant than goats.

should more correctly be called resilience. The terms *trypanotolerance*, *resilience* and *resistance* have been defined as follows: Trypanotolerance - the ability to survive, reproduce and be productive in a tsetse-infested environment in which (cattle) are exposed to infection with pathogenic trypanosomes where other breeds in which this trait is not recognised habitually succumb (Murray *et al.*, 1982);

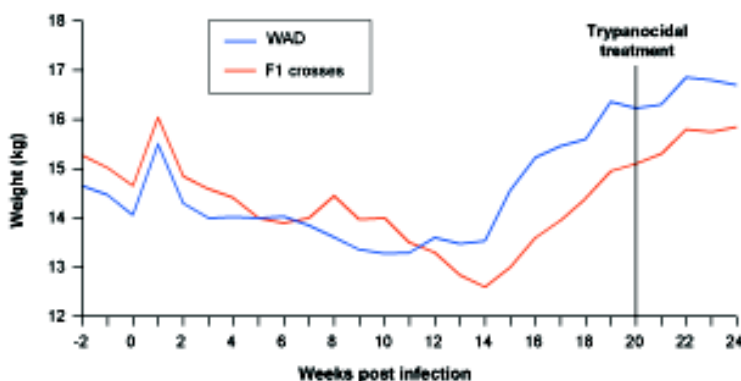


Figure 2. Mean weight (kg) of WAD goats and their F1 crosses infected with *Trypanosoma congolense*.

Bengaly (Burkina Faso), Osaer and Goossens (Gambia) and Touré (Senegal) all conducted experimental infections using Djallonké sheep and found that they

Resistance - a measure of the host's ability to limit the establishment, growth rate, fecundity and/or persistence of a parasite population (Coop & Kyriazakis, 1999);

Resilience - the host's ability to maintain a reasonable level of productivity in the face of a parasitic challenge (Albers *et al.*, 1987).

Goossens *et al.* made that suggestion based on observations that goats are unable to maintain their PCV during infection (Figure 1) although they are able to remain productive. Those observations were more recently confirmed in unpublished studies at ITC (Faye *et al.*, ITC unpublished data), which indicated that Gambian WAD goats being examined at ITC may only exhibit a low degree of trypanotolerance, expressed as a better ability to maintain weight gain (Figure 2). Indeed, there can be significant mortality in goats artificially infected with pathogenic strains of *Trypanosoma congolense*. It is possible that the genotype reared in The Gambia has been 'diluted' with susceptible Sahelian goat breed genes and that, as a result, some of their trypanotolerance has been lost. Phenotypically, Gambian WAD goats appear larger than WAD goats from Guinea. A study is therefore in progress to quantify phenotypic traits and to characterise the genotypes of WAD goats in a north-south transect from Senegal to Guinea, as has been done for cattle (Hill *et al.*, 2001).

The simultaneous phenotypic assessment of the goats will allow links between size or other phenotypic characters and genotype/trypanotolerance to be determined. The desirability for large Sahelian sheep for Tobaski celebrations in West Africa is a factor influencing breeding practices and genotypes of sheep in The Gambia, and probably resulting in a dilution of the trypanotolerant genotype. The Sahelian sheep are generally imported from Senegal but are of increasing interest to Gambian farmers.

In The Gambia, tsetse challenge is generally low, and only about 10% of tsetse feeds are from livestock, the majority being taken from warthogs (Snow, 1979); a lower percentage of feeds are taken from small ruminants. It is clear, therefore, that selection pressure for trypanotolerance in small ruminants is likely to be low and decreasing. Veterinary care is minimal and most livestock owners in rural areas are generally unwilling to pay for treatments for small ruminants even when it appears to be economically worthwhile. An exception is vaccination against PPR, which can cause high mortalities in unvaccinated small ruminants (60%+) especially when associated with secondary

infections such as *Escherichia coli* (Akakpo *et al.*, 1996). Vaccination cover is inadequate however, despite efforts to provide annual nationwide vaccinations.

Resistance to ticks and tick-borne diseases

WAD small ruminants are reputed to be resistant to *Cowdria ruminantium*, however,

and tick-borne disease or dermatophilosis, which is a tick-associated infection. The resistance to ticks observed with N'Dama cattle has a genetic basis (Mattioli *et al.*, 2000). Mattioli *et al.* (1993; 1995; 1998) conducted several experiments in which ticks were collected and counted from one side of the body and the tails of N'Dama and Gobra Zebu. They found

traits making them a valuable resource for the sub-humid region of West Africa.

In addition to this scientific interest in their genetic potential, they are very important as a source of food and income, particularly for the poorer sections of rural communities who cannot afford cattle. Amongst that rural population, women and children particularly benefit from small ruminants, as they are generally the owners or managers. Small ruminants also play an important social role in many West African states.

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Expt. group	Zebu	N'Dama	F1
1	54.2 ± 5.5 ^a	-	-
2	-	20.1 ± 1.6 ^c	24.7 ± 2.8 ^e
3	34.3 ± 2.7 ^b	-	-
4	22.3 ± 1.5 ^g	14.7 ± 0.9 ^d	22.3 ± 2.4 ^f

Table 2. Mean tick burdens of Gobra zebu, N'Dama and Gobra x N'Dama F1 cattle.

Between breeds: ^c significantly different (P<0.001) from ^e; ^d from ^f (P<0.009) and from ^g (P<0.02).

Within breed: ^a significantly different (P<0.002) from ^b; ^c from ^d (P<0.04); ^e from ^f (P<0.05).

Source: Mattioli *et al.*, 1998.

er, there is little documented evidence, and this observation is mainly based on the high mortalities seen in Sahelian breeds when they are brought into The Gambia, where the vector, *Amblyomma variegatum*, is the predominant tick species found on livestock in The Gambia.

Cowdria is endemic in the region and mortalities can also occur in indigenous WAD goats when they are moved from one area to another.

significantly higher numbers of *Amblyomma variegatum* and *Hyalomma* species on the trypanosusceptible Gobra Zebu than on N'Dama (Tables 2 and 3). The corresponding serological prevalence of *Anaplasma marginale* was also lower in N'Dama although there was no significant difference in prevalence of *Babesia bigemina*. These differences were correlated with higher weight gain of N'Dama cattle.

Tick species or genus	Zebu	N'Dama	Level of significance
<i>Amblyomma variegatum</i>	1121	496	< 0.002
<i>Hyalomma</i> spp.	387	132	< 0.001
<i>Boophilus</i> spp.	82	82	n.s.
<i>Rhipicephalus</i> spp.	9	10	Not done
Total	1599	720	Not done

Table 3. Tick counts (whole body + tail) from Gobra zebu and N'Dama cattle (by species/genus).

Genetic resistance to ticks and tick-borne disease in cattle

Trypanotolerance in West African cattle breeds and the East African Orma Boran has been extensively studied over the last 20 years (Trail *et al.*, Paling *et al.*, Dolan, 1998) and is not reviewed here. Less work has been carried out on resistance to ticks

Conclusions

There is some evidence that trypanosomiasis is becoming a less important constraint to livestock production as the distribution and abundance of tsetse decreases. However, it is important to value indigenous West African livestock breeds for their possession of a 'package' of adaptive

