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An attempt to correlate cattle breed origins and diseases associated with or transmitted by the tick *Amblyomma variegatum* in the French West Indies

MAILLARD (J.C.), KEMP, (S.J.), NAVES (M.), PALIN (C.), DEMANGEL (C.), ACCIPE (A.), MAILLARD (N.), BENSALD (A.). Tentative de corrélation de l'origine des races bovines et des maladies associées à ou transmises par la tique *Amblyomma variegatum* dans les Antilles françaises. *Revue Élev. Méd. vét. Pays trop.*, 1993, 46 (1-2) : 283-290

A l'aide de données biologiques et de la recherche historique, on a essayé d'expliquer la différence, en ce qui concerne la résistance et la sensibilité aux maladies transmises par (cowdriose) ou associées à (dermatophilose) la tique *Amblyomma variegatum*, entre deux races bovines des Antilles françaises : la race Créole hybride de la Guadeloupe et le zébu Brahman de la Martinique. Les polymorphismes de 5 systèmes génétiques indépendants (hémoglobine érythrocytaire, albumine et transferrine du sérum, la région classe I du complexe BoLA et le gène gamma S cristallin) ont été étudiés chez différentes races, à savoir des *Bos taurus* d'Europe et d'Afrique, des *Bos indicus* d'Afrique de l'Ouest et de l'Est, le Brahman de la Martinique et le Créole de la Guadeloupe. Par comparaison des fréquences de différents allèles de ces 5 loci polymorphiques non liés et à l'aide de deux matrices mathématiques différentes de NEI et de CAVALLI-SFORZA, on a établi les distances génétiques entre ces races. Il apparaît clairement que le bovin Créole de la Guadeloupe est dans une position intermédiaire entre le *Bos taurus* N'Dama de l'Afrique de l'Ouest et deux races de zébu, *Bos indicus*, le zébu soudanais de l'Afrique de l'Ouest et le Brahman. Grâce aux études d'archives différentes dans les Caraïbes et en Europe, des preuves historiques ont pu être accumulées sur les origines géographiques et sur la chronologie de l'établissement des bovins Créole et Brahman dans les Antilles françaises. La résistance élevée des bovins Créole de la Guadeloupe aux maladies associées à ou transmises par la "tique sénégalaise", *Amblyomma variegatum*, semble due à l'héritage d'un lot de gènes de bovins de l'Afrique occidentale, en particulier de la race N'Dama. En effet, la tique *A. variegatum*, implantée dans toute l'Afrique de l'Ouest, a été introduite dans la région caraïbe avec des bovins ouest-africains. Cette tique a certainement continué à exercer une pression parasitaire, ce qui explique la capacité innée des bovins Créole à maîtriser ces maladies spontanément.

Mots clés : Bovin - Bovin Créole - Bovin N'Dama - Zébu Brahman - Zébu soudanais - Cowdriose - Dermatophilose - Tique - *Amblyomma variegatum* - Résistance aux maladies - Antilles françaises - Guadeloupe - Martinique.

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INTRODUCTION

The Brahman zebu cattle of Martinique is a crossbred population coming from a stabilized mix of different Indian zebu breeds (Gir, Nelore, Gujera) selected in the South of the USA (27, 32) and introduced in this island around 1952. These cattle are very well adapted to the tropical breeding conditions but it is to some extent susceptible to dermatophilosis (5, 11, 12, 26). As a matter of fact, before its introduction in Martinique, this cattle population had never been in contact with the tick *Amblyomma variegatum*. Also, imported "exotic" European breeds are fully susceptible to dermatophilosis and cowdriosis and are in addition not adapted to the tropical conditions.

The Creole cattle of Guadeloupe are a population highly resistant to dermatophilosis and to cowdriosis (5, 11, 43). Phenotypically, they show a more or less important hump but also several taurine features. This capability to resist diseases associated or transmitted by the "Senegalese" bont tick *Amblyomma variegatum* is an innate genetic character which is inheritable and probably maintained by a constant parasitic pressure (1, 12, 22, 29, 37, 44).

It is known for a long time that these cattle are a crossbred between *Bos taurus* and *Bos indicus* breeds, but this fact presumed by zootechnical and phenotypical observations (5) has never been proved by biological data. Furthermore the ancestral breeds of the Creole cattle have never been clearly identified. We have tried to answer several questions. On the one hand, is the *Bos taurus* type coming from European breeds, first introduced during the colonization of the West Indies (27), and/or from African taurines introduced later during trade shipping exchanges (16, 41) ? Does the *Bos indicus* type come from African and/or Indian zebu breeds ?

It is evident that if we could answer these questions, we could explain many breeding traits of this Creole population. Furthermore, it would be possible to include these breeds in comparative studies on genetic research on the improvement of disease resistance and/or zootechnical characters.

MATERIAL AND METHODS

Animals

The polymorphism of 5 genetic systems in the 9 following breeds have been compared (table I):

- 2 European taurine breeds : 139 Friesian and 212 Jersey ;
- 2 African taurine breeds, living in the West African tropical area infested by the tick *Amblyomma variegatum*, and well known to be resistant to several diseases, especially trypanosomosis. These are 1,016 shorthorn Baoule of Burkina Faso and 220 longhorn N'Dama of Guinea ;
- 167 Creole cattle of Guadeloupe ;
- 3 African zebu breeds : 106 Sudan zebus living in the Sahelian area of West Africa, 218 Boran and 393 Kapiti zebus of Kenya in East Africa ;
- 121 Brahman zebus from Martinique.

TABLE I Species, geographical origins and numbers of animals sampled in each population of the different breeds studied.

<i>Bos t. taurus</i>	EUROPE	139 Friesian 212 Jersey
	AFRICA West	1016 Baoule (shorthorn) 220 N'Dama (longhorn)
Crossbreed	GUADELOUPE	167 Creole
<i>Bos t. indicus</i>	AFRICA West	106 Sudan
	AFRICA East	393 Kapiti 218 Boran
	MARTINIQUE	121 Brahman

Techniques

The 5 genetic systems studied were:

- the B chain of haemoglobin which is an erythrocytic protein showing 10 electrophoretic variants. The authors have considered the 2 main alleles A and B detected by electrophoresis on a cellulose acetate support, and well known to be good markers of differentiation in the *Bos* genus between the *taurus* and *indicus* species (4, 6, 8, 30, 31, 33, 35) ;

- the serum albumin displaying 7 variants by polyacrylamide gel electrophoresis (PAGE). As for haemoglobin, the authors have considered the 2 main alleles ; the F (fast) rather characteristic of *Bos taurus* breeds, and the S (slow) more frequent in *Bos indicus* breeds (3, 6, 7, 15, 19, 33, 36, 38) ;

- the serum transferrin also analysed by PAGE showing 6 electrophoretic variants : 2 of them (B and F) are known to be specific for *Bos indicus* zebu breeds (3, 6, 8, 33, 34). The Brahman population of Martinique was not typed for this system ;

- the Bovine Major Histocompatibility Complex : BoLA, highly polymorphic, shows in cattle about 50 allo specificities in the class I region (2, 9, 14, 39). These are serologically detected by the standard method of lymphocytotoxicity. Some antigens of this BoLA class I region are known to be associated with resistance or susceptibility to several diseases but also 2 of them are specific breed markers (25, 40) when considering overall breed populations.

* The KN8 specificity, isolated in Kenya, is a good *Bos indicus* breed marker (17, 25) .

* The KN18 specificity is more interesting because it is not only a *Bos taurus* marker but is above all specific for African taurines (17, 25, 42). Its frequency in European taurines and in zebu breeds is low ;

- the gamma S crystallin gene, investigated by molecular analysis (18) and showing a bi-allelic polymorphism due to a punctual G/C substitution detected at base number 1754. Indeed, after amplification by the PCR technique and separation by agarose gel electrophoresis, two DNA fragments of 128 and/or 149 bp can be detected, each DNA fragment being representative of one of the two alleles.

Mathematical models

By using the frequency differences of these 5 polymorphic loci situated on 5 different chromosomes in the bovine genome, we have established the genetic distances (21) between the 9 breeds. Calculation was based on the two mathematical matrices of NEI (28) and CAVALLI-SFORZA (10).

Historical research

We have studied different historical and commercial archives in the two French West Indies islands of Guadeloupe and Martinique and we have tried to summarize numerous specialized books and bibliographical references (16, 20, 41).

RESULTS AND CONCLUSIONS

In the B haemoglobin system, where the A allele is a marker of *Bos taurus* breeds (frequency always higher than 90 % whereas in *Bos indicus* it rarely exceeds 50 %), it was noticed (figure 1) that the Brahman frequency (55 %) is closer to the zebu average while the Creole one (71 %) indicates clearly an intermediate value between *Bos taurus* and *Bos indicus*.

In the serum albumin system, where the F allele is also a marker of *Bos taurus* breeds, it is observed here again (figure 2), an intermediate frequency of 52 % for the Creole breed whereas the Brahman value is closer to the other zebu breeds.

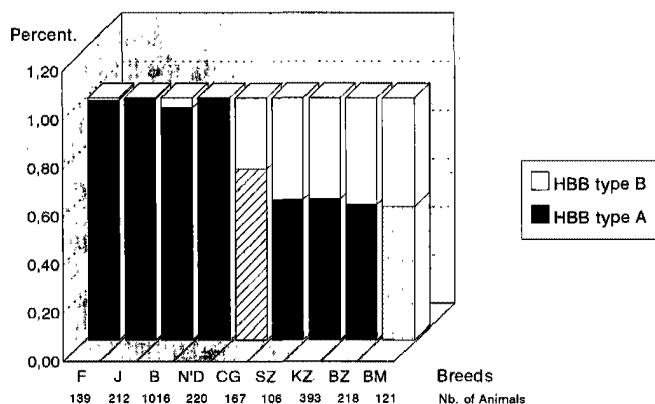


Figure 1 : Haemoglobin B type polymorphism : Allele frequencies (in percentage) in different cattle breeds : F = Friesian, J = Jersey, B = Baoule, N'D = N'Dama, CG = Creole Guadeloupe, SZ = West African Sudan Zebu, KZ = East African Kapiti Zebu, BZ = East African Boran Zebu, BM = Brahman Martinique.

The frequency of the A allele which is a taurine marker indicates in the Creole of Guadeloupe, an intermediate value (71 %) between *Bos taurus* and *Bos indicus*, whereas the Brahman frequency (55 %) is closer to the zebu average. (Data sources : CIRAD-EMVT, INRA, ILRAD, AFRC/ABRO)

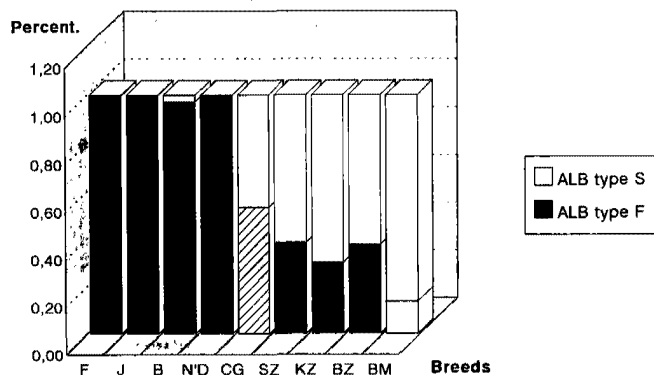


Figure 2 : Albumin type polymorphism : Allele frequencies (in percentage) in different cattle breeds (see figure 1).

The frequency of the F allele which is also a taurine marker indicates in the Creole of Guadeloupe, an intermediate value (55 %) between *Bos taurus* and *Bos indicus*, whereas the Brahman frequency is 12 %. (Data sources : CIRAD-EMVT, INRA, ILRAD, AFRC/ABRO)

The results obtained from these two systems of haemoglobin and albumin show evidence for the presence of taurine features in the Creole population of Guadeloupe.

Concerning the transferrin system :

- for the B allele, (figure 3) the Creole displays a frequency which is very similar to that of zebu breeds, whereas for the taurine breeds the allele B is completely absent ;

- for the F allele, the same phenomenon can be observed (figure 4) suggesting also the presence of *Bos indicus* blood in the Creole breed.

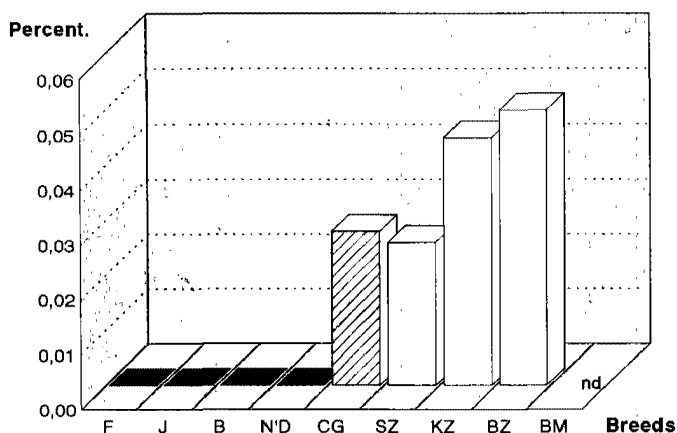


Figure 3 : Transferrin B type polymorphism : Allele frequencies (in percentage) in different cattle breeds (see figure 1) (nd = not determined).

The Creole frequency is very similar to those of zebu breeds, whereas this allele is completely absent in the taurine breeds. (Data sources : CIRAD-EMVT, CRTA, ILRAD, AFRC/ABRO)

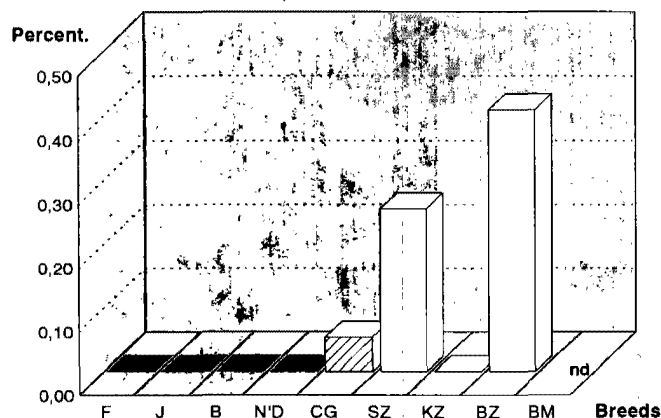


Figure 4 : Transferrin F type polymorphism : Allele frequencies (in percentage) in different cattle breeds (see figure 1) (nd = not determined).

The Creole frequency indicates an intermediate value between *Bos indicus* and *Bos taurus* breeds where this allele is absent. (Data sources : CIRAD-EMVT, CRTA, ILRAD, AFRC/ABRO)

In the BoLA Complex:

- the frequencies of the KN8 specificity (figure 5) confirm the previous results shown with the transferrin polymorphisms, that the Creole breed possesses this zebu marker, as expected for the Brahman zebu ;

- high frequencies of the KN18 specificity (figure 6) are characteristic of West African *Bos taurus* populations whereas this specificity has only been found in a very low

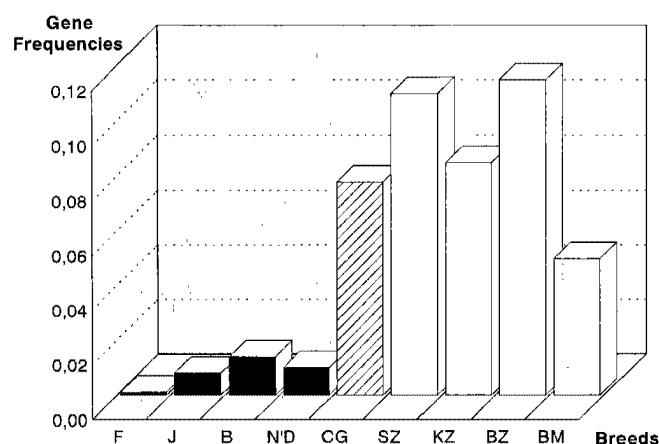


Figure 5 : Polymorphism of the KN8 specificity in the BoLA Complex : Gene frequencies in different cattle breeds (see figure 1).

The Creole frequency of this specificity is closer to those of *Bos indicus* breeds including Brahman. (Data sources : CIRAD-EMVT, ILRAD)

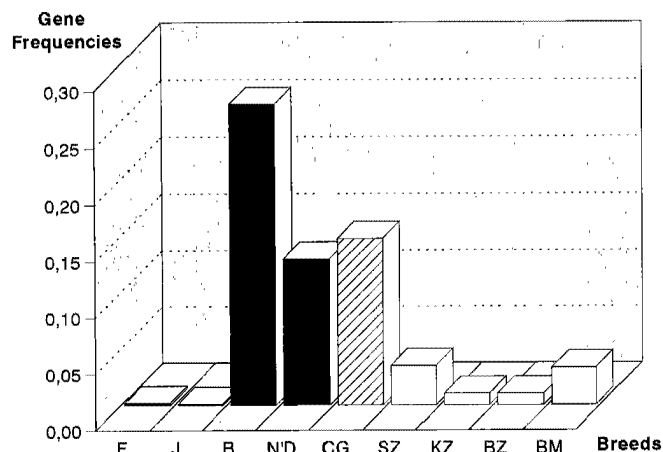


Figure 6 : Polymorphism of the KN18 specificity in the BoLA Complex: Gene frequencies in different cattle breeds (see figure 1).

The Creole frequency of this specificity is closer to those of the 2 African *Bos taurus* breeds : N'Dama and Baoule, indicating its African taurine origin. Indeed, this KN18 antigen is specific to African taurine being almost absent in European taurine breeds. The frequency of the Brahman population is normally closer to those of other *Bos indicus* breeds. (Data sources : CIRAD-EMVT, ILRAD)

level in cattle from Northern Europe. For this reason, a KN18 frequency of 15 % in the Creole population is highly significant in determining the partial West African *Bos taurus* origin of the Creole breed. This result strongly suggests that Creole cattle have acquired their taurine features not only from European *Bos taurus* but also from African *Bos taurus* .

For the gamma S crystallin gene polymorphism, it is found (figure 7) that the allele represented by the 128 bp fragment is monomorphic at 100 % in the Creole population. The most similar frequency of this allele is encountered in the African N'Dama (85 %). This result confirms the previous hypothesis obtained with MHC-BoLA typing, viz. that some of the Creole taurine features have been inherited from an N'Dama ancestor.

The two dendrograms obtained by the calculations of genetic distance indicate clearly (figure 8), the intermediate position of the Creole breed of Guadeloupe between the N'Dama *Bos taurus* breed of West Africa and two zebu breeds, the Sudan zebu of West Africa and the Brahman. In the NEI dendrogram the Creole is closer to the African taurine group and far from the European taurine breeds. In the CAVALLI-SFORZA dendrogram the Creole is closer to the zebu group but the N'Dama remains the nearest taurine breed. This slight difference could be explained by the existence of a close equilibrium between *Bos taurus* and *Bos indicus* types.

Regarding the historical approach, evidence have been accumulated suggesting the following chronology of the establishment of cattle in the French West Indies.

When Christopher Columbus discovered the Caribbean islands in 1492, there was no domestic livestock.

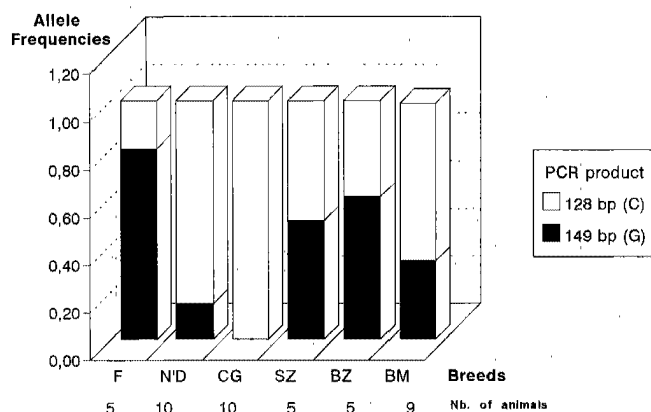


Figure 7 : G/C Bi-Allelic polymorphism of the Gamma S Crystallin gene in different cattle breeds (see figure 1).

The allele represented by a 128 bp fragment is monomorphic at 100 % in the Creole population and the most similar frequency of this allele is the one of the African N'Dama with 85 %. This indicates once again the African *Bos taurus* N'Dama origin of the Creole crossbred. (Data sources : CIRAD-EMVT, ILRAD)

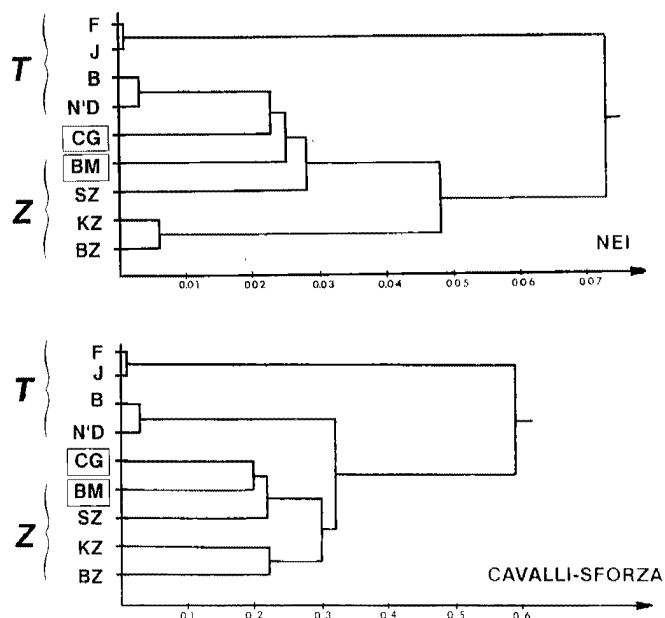
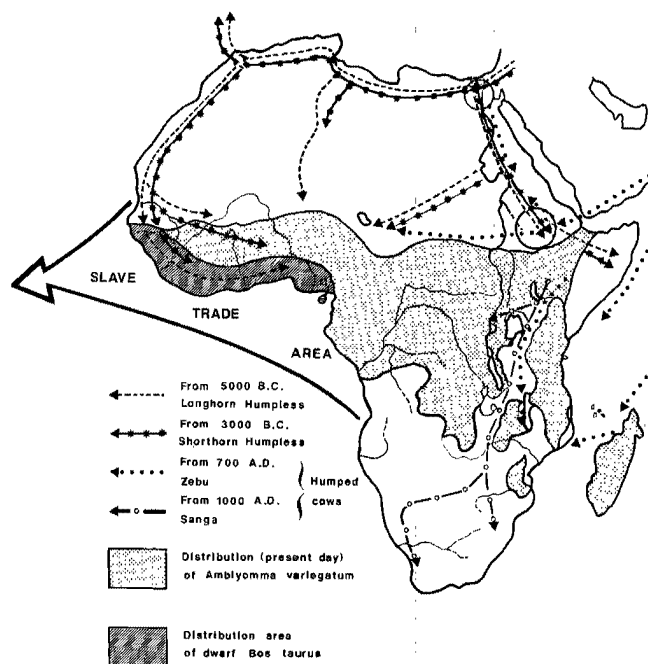


Figure 8 : Dendrograms of genetic distance are obtained by using the two different mathematical matrices of NEI and CAVALLI-SFORZA in different cattle breeds (see figure 1).

It can be seen clearly in the two dendrograms the intermediate position of the Creole breed of Guadeloupe between the N'Dama *Bos taurus* breed of West Africa and two zebu breeds, the West African zebu and the Brahman. In the NEI dendrogram the Creole is closer to the African taurine group and far from the European taurine breeds. In the CAVALLI-SFORZA dendrogram the Creole is closer to the zebu group but the N'dama remains the nearest taurine breed. This slight difference could be explained by the existence of a close equilibrium between *Bos taurus* and *Bos indicus* types.

All during the colonization period from the XVth to the XVIIIth century, the cattle which populated these islands were imported from Europe, mainly from Spain and Portugal, but a few from France. At the same time, African cattle were probably also imported from the Spanish, Portuguese and French colonial establishments of Africa, which were located essentially all along the Guinea Gulf Coast (map 1). These dwarf, humpless and shorthorn *Bos taurus* cattle have been established for 7,000 years (13) in this area infested by the tick *Amblyomma variegatum*. It was well adapted to the tropical environment and was resistant to certain tropical diseases. In this way it is possible that these cattle could be responsible for the introduction of *Amblyomma variegatum* into the Caribbean islands, since the XVth century. Its survival during some weeks of shipping was probably possible by completing its development cycle on different hosts during the journey. Arriving in the tropical environment of the Caribbean islands, this tick was able to acclimatize.



Map 1 : Map of Africa showing the foci of origin and time of subsequent spread in indigenous breeds of African cattle. Data are based on PAYNE (1964) and EPSTEIN (1971). The distribution area of African *Bos taurus* either longhorn or shorthorn lies all along the Guinea Gulf Coast and is included in the distribution area of the tick *Amblyomma variegatum*. The Spanish, Portuguese and French colonial establishments were mainly based in these areas between the South of Senegal and Angola.

This tick could have existed in small numbers, without visible pathologic consequences on cattle, before 1828 when its introduction is presumed to have occurred with zebu cattle of Senegal. These cattle of African origin might have resisted diseases associated or with transmitted by *Amblyomma variegatum*, whereas the cattle of European origin might have disappeared progressively.

During the XIXth century, African cattle were imported again : mainly zebras from Senegal to improve the phenotypic aspects necessary for cart traction in sugar cane cultivation, and pure or crossbred N'Dama cattle from the Gambia (24). This African zebu also originated from an area infested with *Amblyomma variegatum*, and was accustomed to the environmental conditions. It was crossbred with the taurine cattle of African origin (such as the Senepol breed of the Virgin Islands which is a crossbred population between 2 *Bos taurus* breeds: African N'Dama of Senegal and European Red Poll). The heterosis effect could improve the resistance phenomenon in the areas infested by *Amblyomma variegatum* where the constant parasitic pressure maintained this genetic predisposition.

All during the XXth century, the African zebu type was gradually replaced by Indian zebu breeds imported since, from the French establishments of India and from Venezuela. At the present time, this crossbreeding is continuing with Brahman zebu selected in the USA. Also, different attempts at crossbreeding with European breeds for zootechnical improvements were severe failures because of disease.

At present, have been studied 5 distinct polymorphic loci situated in 5 distinct chromosomes out of the 26 autosomal chromosomes constituting the bovine genome. It is therefore impossible to conclude with certainty on the exact phylogeny of the French West Indies cattle populations. Contribution of Spanish and Portuguese cattle to the taurine features of the Creole breed needs to be assessed because these cattle are the ancestors of the Criollo *Bos taurus* breed widely distributed in South America and in the Spanish Caribbean islands. Origin and genetic characteristics of European breeds have been recently studied in relation to Indian and African cattle (23, 24). These studies performed by using molecular techniques have revealed new molecular markers, one of them associated with the Y chromosome, allowing to distinguish *Bos taurus* from *Bos indicus* genotypes.

In the light of these results, the authors plan to further investigate the genetics of the French West Indian cattle by including Spanish and Portuguese breeds in our present panel. The rationale of these studies is to define gene pools in different breeds known to be resistant or susceptible to diseases in order to preserve these gene pools in future breeding programs.

The authors also think that it could be very interesting and useful to pursue their historical investigations by studies of other archives in several countries. These could be the formerly colonized countries like Trinidad, St Domingo, Cuba and Puerto Rico in the Caribbean, and the formerly colonizing countries like Spain, Portugal and France.

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MAILLARD (J.C.), KEMP (S.J.), NAVES (M.), PALIN (C.), DEMANGEL (C.), ACCIPE (A.), MAILLARD (N.), BENSAÏD (A.). An attempt to correlate cattle breed origins and diseases associated with or transmitted by the tick *Amblyomma variegatum* in French West Indies. *Revue Élev. Méd. vét. Pays trop.*, 1993, **46** (1-2) : 283-290

By using biological data and historical research, we have tried to explain the difference between resistance and susceptibility to the diseases transmitted (cowdriosis) or associated (dermatophilosis) with the tick *Amblyomma variegatum*, in two cattle breeds of the French West Indies: the Creole crossbred cattle of Guadeloupe and the Brahman zebu cattle of Martinique. Have been studied the polymorphisms of 5 independent genetic systems (erythrocytic haemoglobin, serum albumin and transferrin, the class I region of the BoLA complex and the gamma S crystallin gene) in different breeds comprising *Bos taurus* cattle of Europe and Africa, *Bos indicus* of West and East Africa, as well as the Brahman of Martinique and the Creole crossbred of Guadeloupe. By comparing the different allele frequencies of these 5 non related polymorphic loci and by using the two different mathematical matrices of NEI and of CAVALLI-SFORZA, have been established the genetic distances between these breeds. It appears clearly that the Creole cattle of Guadeloupe are in an intermediate position between the *Bos taurus* N'Dama breed of West Africa and two *Bos indicus* zebu breeds, namely the West African Sudan zebu and the Brahman. Thanks to studies of different archives in the Caribbean and in Europe, historical evidence have been accumulated on the geographical origins and on the chronology of the establishment of Creole and Brahman cattle in the French West Indies. The high resistance of the Creole cattle of Guadeloupe to diseases associated with or transmitted by the "Senegalese" tick *Amblyomma variegatum* seems to be due to the inheritance of a pool of genes from West African cattle and more particularly from the N'Dama breed. Indeed, the tick *Amblyomma variegatum*, endemic in all West Africa, was introduced in the Caribbean with West African cattle. Most certainly, this tick maintained a parasitic pressure, hence the innate capability of the Creole cattle to naturally control these diseases.

Key words : Cattle - Creole cattle - N'Dama cattle - Brahman zebu cattle - Sudan zebu cattle - Heartwater - Dermatophilosis - Tick - *Amblyomma variegatum* - Disease resistance - French West Indies - Guadeloupe - Martinique.

MAILLARD (J.C.), KEMP (S.J.), NAVES (M.), PALIN (C.), DEMANGEL (C.), ACCIPE (A.), MAILLARD (N.), BENSAÏD (A.). Intento de correlación entre las razas bovinas y las enfermedades relacionadas o transmitidas por la garrapata *Amblyomma variegatum* en las Antillas francesas. *Revue Élev. Méd. vét. Pays trop.*, 1993, **46** (1-2) : 283-290

Mediante el uso de datos biológicos e históricos, se trata de explicar la diferencia entre la resistencia y la susceptibilidad a las enfermedades transmitidas (por ejemplo la cowdriosis) o asociadas (por ejemplo la dermatofilosis) con el ácaro *Amblyomma variegatum*, en dos razas de ganado de las Antillas Francesas : cruce autóctono (Criollo) de Guadelupe y ganado Brahman de Martinica. Se estudiaron los polimorfismos de cinco sistemas genéticos independientes (hemoglobina eritrocítica, albúmina sérica y transferrina, complejo de clase I de BoLA y gen cristalino gama S), en diferentes razas de ganado *Bos taurus* europeo y *Bos indicus* de África del Este y del Oeste, incluyendo el cruce autóctono (Criollo) de Guadelupe y el ganado Brahman de Martinica. Las distancias genéticas de estas razas, se establecieron mediante la comparación de las frecuencias alélicas de estos 5 loci polimórficos e independientes y el uso de dos matrices matemáticas diferentes, de NEI y CAVALLI-SFORZA. Parece claro que el ganado Criollo de Guadelupe se encuentra en una posición intermedia entre el *Bos taurus* N'Dama de África del Oeste y dos razas cebuinas de *Bos indicus*, el cebú Sudanés de África del Oeste y el Brahman. Gracias a los estudios de diferentes archivos, tanto en el Caribe como en Europa, logramos acumular la evidencia histórica sobre los orígenes geográficos y cronológicos del establecimiento del ganado Criollo y Brahman en las Antillas Francesas. La alta resistencia del ganado Criollo de Guadelupe a las enfermedades asociadas o transmitidas por la garrapata "senegalesa" *Amblyomma variegatum*, parece ser debida a la carga hereditaria de un "pool" de genes de ganado de África del Oeste y particularmente de la raza N'Dama. De hecho, *Amblyomma variegatum*, endémica en África del Oeste, fue introducida en el Caribe junto con el ganado del oeste africano. Aparentemente, este ácaro ha mantenido una presión parasitaria suficiente para la conservación de la capacidad natural del ganado Criollo para el control de este tipo de enfermedades.

Palabras claves : Bovino - Bovino Criollo - Bovino N'Dama - Cebú Brahman - Cebú Sudanés - Cowdriosis - Dermatofilosis - Garrapata - *Amblyomma variegatum* - Resistencia a las enfermedades - Antillas francesas - Guadelupe - (La) Martinica.