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ANIMAL GENETIC RESOURCES INFORMATION

BULLETIN D'INFORMATION SUR LE RESSOURCES GÉNÉTIQUES ANIMALES

BOLETIN DE INFORMACION SOBRE RECURSOS GENETICOS ANIMALES

Food and Agriculture Organization of the United Nations
Organisation des Nations Unies pour l'alimentation et l'agriculture
Organización de las Naciones Unidas para la Agricultura y la Alimentatción

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Initiative for Domestic Animal Diversity
Initiative pour la Diversité des Animaux Domestiques
Iniciativa para la Diversidad de los Animales Domésticos

Editors - Editeurs - Editores:
S. Galal & J. Boyazoglu

Viale delle Terme di Caracalla 1, 00100 Rome, Italy

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Editorial

Recent Developments in the Global Strategy for the Management of Animal Genetic Resources

FAO has, since the early 1960s , provided technical assistance to countries to identify and better manage their animal genetic resources and develop conservation strategies. In 1993 the Global Strategy for the Management of Farm Animal Genetic Resources (Global Strategy) was initiated with its technical and structural constituents. Since the early nineties serious efforts have been and are being made to institutionalise the activities in farm animal genetic resources at the country and global levels. This entails not only technical activities but also establishing structures, and institutions that will enhance discussion and decision making among formal and informal bodies with regard to animal genetic resources (AnGR). Within FAO this process has to go through different governing bodies composed of its over 170 member nations.

FAO has had a Commission on Plant Genetic Resources that was broadened in 1995 to include other organisms used for food and agriculture, beginning with animal genetic resources. At the Seventh Session of the Commission on Genetic Resources for Food and Agriculture, in May 1997, the Commission agreed to establish a subsidiary Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture (ITGW), i.e. the first AnGR intergovernmental structure to ensure direct government involvement and continuity and support. The first ITWG session was successfully held in 8-10 September 1998 at FAO, Rome, to consider the Further development of the Global Strategy for the Management of Farm Animal Genetic Resources (AnGR). The ITGW is composed of 27 countries elected to ensure regional balance. The session was well attended by 64 member and observer countries plus many international, regional and non-governmental organisations. The convenors reached recommendations that could be summarised in:

- further shape and develop the Global Strategy constituents;
- countries to urgently identify AnGR National Focal Points/Co-ordinators and Regional Focal Points to facilitate/co-ordinate network development and action; and
- FAO to co-ordinate a Country-driven *Report on The State of the World's Animal Genetic Resources*.

Thus a significant step has been taken for the countries to develop ownership of the Global Strategy.

The Editors

Editorial

Progrès récents dans la Stratégie Mondiale pour la Gestion des Ressources Génétiques Animales

Depuis le début des années 60 la FAO a donné son assistance technique aux pays pour identifier et obtenir une meilleure gestion de leurs ressources génétiques animales et pour développer des estratégies de conservation. En 1993 on a commencé la Stratégie Mondiale pour la Gestion des Ressources Génétiques des Animaux Domestiques (Stratégie Mondiale) avec les parties techniques et structurelles.

Dès le début des années 90 des efforts importants ont été réalisés, et encore aujourd'hui, pour institutionnaliser les activités dans le domaine des ressources génétiques des animaux domestiques au niveau national et international. Tout ceci entraîne, non seulement une série d'activités techniques, mais aussi l'établissement de structures et d'institutions qui puissent permettre la discussion et la prise de décision des organismes, officiels ou non, pour tout ce qui concerne les ressources génétiques animales (AnGR). A l'intérieur de la FAO ce processus doit passer à travers les différents corps gouvernementaux appartenants aux 170 pays membres.

La FAO comptait déjà avec une Commission pour les Ressources Génétiques Végétales qui, en 1995, a été élargie pour inclure d'autres organismes chargés des aliments et de l'agriculture, à commencer par les ressources génétiques animales. Pendant la Septième Séance de la Commission pour les Ressources Génétiques Alimentaires et de l'Agriculture, en mai 1997, la Commission a accordé d'établir un Groupe Technique de Travail Intergouvernemental subsidiaire pour les Ressources Génétiques Animales pour l'Alimentation et l'Agriculture (ITWG); par exemple, la première structure intergouvernementale de AnGR pour assurer le compromis au niveau gouvernemental, ainsi que la continuité et l'appui nécessaires. La première séance du ITWG a été organisée avec succès au siège de la FAO à Rome du 8 au 10 septembre 1998, et a pris en considération le Futur développement de la Stratégie Mondiale pour la Gestion des Ressources Génétiques des Animaux Domestiques (AnGR). Le ITWG est formé par 27 pays élus de façon équilibrés par rapport aux différentes régions. A la séance ont participés 64 pays membres, d'autres pays en tant qu'observateurs, ainsi que des organisations internationales, régionales et non gouvernementales. Le groupe a émis une série de recommandations qui peuvent être résumes comme suit:

- continuer avec le développement et modélation des composantes de la Stratégie Mondiale;
- que les pays identifient au plus tôt les Point Focaux Nationaux pour AnGR/facilitent les Coordonnateurs et les Points Focaux Régionaux/coordonnent le développement et travail du réseau; et
- que la FAO coordonne pour chaque pays un *Rapport sur l'Etat des Ressources Génétiques Animales dans le Monde*.

En conclusion, un pas important a été fait pour que les pays puissent réaliser le développement de leur propre Stratégie Mondiale.

Les Editeurs

Editorial

Progresos recientes en la Estrategia Mundial para la Gestión de los Recursos Genéticos Animales

Desde el inicio de los años 60 la FAO ha proporcionado asistencia técnica a los países para identificar y conseguir una mejor gestión de sus recursos genéticos animales y para desarrollar estrategias de conservación. En 1993 se inició la Estrategia Mundial para la Gestión de los Recursos Genéticos de Animales Domésticos (Estrategia Mundial) en sus partes técnicas y estructurales. Desde principios de los años 90 se han ido realizando, y se siguen haciendo, importantes esfuerzos para institucionalizar las actividades en el campo de los recursos genéticos de los animales domésticos a nivel nacional e internacional. Todo esto conlleva no sólo actividades técnicas, sino también el establecimiento de estructuras e instituciones que permitan la discusión y la toma de deciones de los organismos, oficiales o no, en todo lo que concierne los recursos genéticos animales (AnGR). Dentro de la FAO, este proceso tiene que pasar a través de diversos cuerpos gobernativos pertenencientes a los 170 países miembros.

La FAO contaba ya con una Comisión para Recursos Genéticos Vegetales que en 1995 fue ampliada para incluir otros organismos que se encargaban de los alimentos y de la agricultura, empezando con los recursos genéticos animales. Durante la Séptima Sesión de la Comisión para los Recursos Genéticos Alimentarios y de la Agricultura, en mayo de 1997, la Comisión acordó establecer un Grupo Técnico de Trabajo Intergubernamental subsidiario sobre Recursos Genéticos Animales para la Alimentación y la Agricultura (ITGW), por ejemplo, la primera estructura intergubernamental de AnGR para asegurar el compromiso a nivel gubernamental, así como la continuidad y apoyo necesarios. La primera sesión del ITWG se llevó a cabo con éxito en la sede de la FAO en Roma del 8 al 10 de septiembre de 1998, y tomó en consideración el Futuro desarrollo de la Estrategia Mundial para la Gestión de los Recursos Genéticos de Animales Domésticos (AnGR). El ITWG está compuesto por 27 países elegidos de forma equilibrada con respecto a las diferentes regiones. A la sesión asistieron 64 miembros y países observadores, así como organizaciones internacionales, regionales y no gubernamentales. El grupo emitió una serie de recomendaciones que pueden resumirse como sigue:

- seguir con el desarrollo y remodelación de los componentes de la Estrategia Mundial;
- que los países identifiquen urgentemente los Puntos Focales Nacionales para AnGR/faciliten los Coordinadores y Puntos Focales Regionales/coordinen el desarrollo y actuación de la red; y
- que la FAO coordine para cada país un *Informe sobre el Estado de los Recursos Genéticos Animales en el Mundo.*

En conclusión, un paso importante ha sido realizado para que los países lleven a cabo el desarrollo de su propia Estrategia Mundial.

Los Edirores

El ganado criollo Romosinuano (Romo)

G. Martínez Correal

Instituto Colombiano Agropecuario (ICA) Apartado Aéreo 2011
***Villavicencio**, Meta, Colombia S.A.*

Resumen

Este artículo reseña el origen del ganado criollo colombiano Romosinuano (Romo), el Valle del río Sinú, Costa Norte de Colombia. También, se describen las características zootécnicas de la raza, sus cualidades y aptitudes productivas como raza pura y en cruzamientos. Se presentan los resultados de heterosis, individual y materna, de características de crecimiento pre y posdestete, el cálculo de producción de carne al destete por vaca expuesta a toro en el hato, el peso presacrificio y el rendimiento en canal del Romo puro y sus cruces con Cebú (Brahman) y Charolais.

Summary

This paper outlines the origin of the Colombian Creole cattle Romosinuano (Romo) in the Sinu Valley, North Coast of Colombia. The zootechnical characteristics of the breed, its qualities and productive aptitudes as a pure breed and as a crossbreed are also described. The individual and maternal heterosis of pre and post-weaning growth traits, the estimation of beef production at weaning per cow exposed in the breeding herd, the pre-slaughter weight and dressing percentage of Romo and its crosses with Zebu (Brahman) and Charolais are presented.

***Key words:** Criollo breeds, Colombia, Zebù, Beef cattle, Heterosis, Crossbreeding.*

Introducción

El ganado criollo Romosinuano debe su nombre a la carencia de cuernos (topo o romo) y lugar de origen, el Valle del río Sinú, Costa Norte de Colombia. El Valle del Sinú, en su parte baja, corresponde a la zona climatológica de Bosque Seco Tropical (BST), con temperatura media de 27,5ºC; 83% de humedad relativa y 1 200 milímetros (mm) de precipitación anual, distribuidos en dos épocas: una de baja (diciembre a marzo) y otra de alta precipitación (abril a noviembre) (Hernández, 1976b).

Con extensión aproximada de 425 000 ha, el Sinú es un valle fértil con suelos profundos de textura franco-arcillosa, ricos en N, P, Ca K y con pH cercano a la neutralidad. Debido a su perfil plano y baja permeabilidad, el principal problema de sus suelos es su mal drenaje. Se encuentra cubierto por gran cantidad de gramíneas y leguminosas, nativas e introducidas. Las gramíneas introducidas más comunes son los pastos Pará (*Brachiaria mutica*), Pangola (*Digitaria decumbens*), Guinea (*Panicum maximum*), Angleton (*Dichantium aristatum*), Puntero (*Hiparrhenia rufa*) y *Brachiarias* spp, entre los que se destacan el *B. decumbens* y *B. dictyoneura*. El árbol forrajero más común es el Matarratón (*Gliricida sepium*) y entre las leguminosas nativas sobresalen las de los géneros *Desmodium* y *Phaseolus* (Pinzón, 1984).

El Ministerio de Agricultura de Colombia estableció, en 1936, un grupo de ganado Romo en la Granja de Montería, hoy conocida como Centro de Investigaciones (CI) Turipaná, (Cereté, Córdoba), con el propósito

Figure 1. Vaca y ternera joven.

Figure 2. Grupo para apareamiento en un rancho de llanuras del este de Colombia.

de conservar, multiplicar, fomentar y estudiar la raza. A partir de 1967 se iniciaron trabajos de evaluación productiva del Romo y sus híbridos con Cebú (Brahman), Charolais y Santa Gertrudis (Hernández, 1976b).

Reseña Histórica

El primer ganado venido al Nuevo Mundo lo trajo Colón en su segundo viaje y se desembarcó en la isla de Santo Domingo, en noviembre de 1493. Dos décadas más tarde pasó a Puerto Rico, Jamaica, Cuba y territorio continental, dando origen al ganado de Norte, Centro y Sur América (Rouse, 1977). Santa Marta y Cartagena de Indias fueron los puertos de entrada del ganado a Colombia (Rouse, 1970; Salazar y Cardozo, 1981; Pinzón, 1984).

Sobre la carencia de cuernos de la raza existen varias teorías, todas ellas coinciden en que se originó de los ganados traídos al Nuevo Mundo por los conquistadores españoles. Según Pinzón (1981), ejemplares acornes se presentaban en forma esporádica en los ganados que poblaron el Sinú y aun cuando en un principio no gustaban, posteriormente se popularizaron, debido a que se asoció el rasgo topo o romo con mejores características para matadero. Pinzón considera que se presentó una mutación en el ganado criollo colombiano Costeño con Cuernos (CCC), oriundo de la zona y que por tanto el Romo es una raza criolla auténtica colombiana; la topización espontánea (mutación) se ha presentado en diversas razas y no habría razón para considerar que el carácter topo sea esencialmente producto de cruzamiento.

En Colombia existen otros casos de ganados criollos acornes que han aparecido espontáneamente y Martínez (1992) menciona una variedad "topa" en ganado criollo colombiano Blanco Orejinegro (BON).

Hernández (1976b) considera que la hipótesis más probable es la de cruzamiento de vacas de la raza criolla colombiana CCC con toros de razas sin cuernos, los cuales, debido a la dominancia genética de este rasgo y a la preferencia que se mostró por este tipo de animales, diseminaron rápidamente dicha

Figure 3. Toro y vaca.

Figure 4. Vaca de ocho años de edad de 600 kg.

característica. Las razas más probables en la formación del carácter tipo en el Romo, según la anterior hipótesis, son el Red Angus y el Red Poll.

Cualquiera que haya sido el origen del Romo, lo importante es el proceso de adaptación que ha experimentado en el amplio rango de ambientes y niveles de manejo a que ha sido sometido en distintas regiones de la geografía colombiana; el Romo es la raza criolla más difundida en el país y la única que ha sido exportada, inclusive a los Estados Unidos de Norte América. En el año de 1949 se llevaron unas pocas dosis de semen de Romo que fue utilizado en cruzamiento absorbente con ganado Hereford. Descendientes de los individuos llevados a los EE.UU. parecen ser los ancestros del ganado que posteriormente pasó al CATIE, Turrialba, Costa Rica (Pinzón, 1981).

Rico y col. (1986) reportaron, en 53 fincas de diferentes regiones de Colombia, una población total de 3 262 animales puros; además, 2 563, 2 665 y 264 individuos de alto (>75%), medio (0-50%) y bajo (<0-25%) mestizaje, respectivamente. La Asociación Colombiana de Criadores de Ganado Romosinuano (ASOROMO), reporta una tendencia al incremento de la población y las siguientes estadísticas de productores y número de animales en 1994: 6 000 animales registrados desde la creación de la Asociación y una población actual de 3 500 en 28 explotaciones en diferentes zonas del país. También reporta exportaciones a Venezuela de material seminal y, aproximadamente, 800 animales.

Características Externas del Romosinuano

Apariencia general

El rasgo más típico es la ausencia de cuernos. El color de la capa va de amarillo claro (bayo) a rojo encendido (castaño oscuro o cereza); también existen animales *hoscos:* bayos o castaños con cabeza y extremidades negras. El color de la capa es uniforme, pero algunos animales presentan pequeñas manchas circulares de color más intenso, esparcidas en todo el cuerpo y que le dan al animal un aspecto *moteado*, "*pataconeado*", como de tela estampada. Según el profesor J.C. Bonsma, citado por Pinzón (1981): "El moteado o estrellas de melanina o "pataconeado" sobre la piel es un indicador de alta vascularidad y buena salud. Esas estrellas son el resultado de una irrigación sanguínea muy eficiente".

Las mucosas y la piel son, en general, de tonos claros, pero en los hoscos estas son de color negro. La piel es gruesa y bien adherida, y el pelo es, corto, brillante y grasoso. El Romo es de talla mediana y cuerpo cilíndrico;

Cuadro 1. Raza Romosinuano. Adaptado de: Hernández, B. G. (1976b); Rincón, R. (1991).

Medidas corporales (cm.)	Machos	Hembras
Alzada a la cruz	131,5	123,5
Perímetro torácico	192,5	175,5
Longitud escápulo-isquial	159,5	145,5
Peso vivo (kg)	573,1	412,2

Figure 5. Toro F_1 Romo x Brahaman heifer (RXB) de dos años y 400 kg .

la raíz de la cola es descarnada, de inserción alta y escasa borla (Hernández, 1976b; Rincón, 1991). En el cuadro 1 se presentan los promedios no ponderados de pesos y medidas corporales de animales de cuatro (4) años de edad.

Características fisiológicas

La característica fisiológica más sobresaliente del Romo es su adaptación al trópico, adaptación traducida en excelentes índices de fertilidad, supervivencia o longevidad; igualmente, sobresale por su rusticidad, habilidad combinatoria y producción de heterosis, especialmente con Cebú.

El sobresaliente comportamiento reproductivo que esta raza exhibe, no sólo en las condiciones del Sinú sino en otras regiones más inhóspitas del país, ha sido reportado por diferentes autores. En 1940, Escobar, citado por Pinzón (1981), encontró, en el Sinú, que el 79% de las vacas entraban en celo antes de los 60 días posparto y el 92% antes de los 69 días; posteriormente, Hernández (1970), en el C.I. Turipaná, reportó un promedio de 373,6 días de intervalo entre partos, con 54,3% de ellos inferiores a 365 días. Según Hernández (1981), la longevidad y fertilidad del ganado Romo compensan el aparente retraso en su desarrollo, ya que es común encontrar vacas de 15 ó más años de edad con 12 ó más partos, lo que es más económico que tener vacas de mayor velocidad de crecimiento, pero con menor número de crías en su vida productiva.

El Romo es tolerante a los excesos de calor y humedad del trópico, así como a otras contingencias desfavorables: excesiva presencia de parásitos externos e internos, plagas y enfermedades. Un aspecto importante de su adaptación a zonas húmedas es la calidad de las pezuñas, que lo habilitan para soportar el fango de las inundaciones periódicas en el Valle del Sinú (Pinzón, 1981).

Resultados Experimentales

Reproducción y supervivencia

Los resultados que se relacionan en los cuadros 2, 3, 4 y 5 corresponden a investigaciones realizadas en el C.I. Turipaná, durante los años 1970 a 1976. En el cuadro 2 se presentan las tasas de natalidad, mortalidad y destete, basadas en el total de vacas expuestas, en grupos de apareamiento de Romo (R) y Cebú (C) puros, sus recíprocos

Cuadro 2. Porcentajes de natalidad, mortalidad y destete de cruces de Romo, Cebú, cruces recíprocos y retrocruces. Turipaná. 1970-1976. Adaptado de Hernández, B. G. (1976b; 1981).

Razas Toro Vaca	No. vacas	Natalidad %	Mortalidad %	Destete %
Romo Romo	624	81,1	3,2	78,5
Romo Cebú	193	77,7	4,0	74,6
Cebú Romo	333	52,0	3,6	50,1
Cebú Cebú	493	74,4	8,2	68,3
Romo F_1 CxR	234	82,9	3,6	79,9
Cebú F_1 RxC	53	77,4	2,4	75,5

Figure 6. Toro adulto de cinco años y 750 kg.

RxC, CxR y retrocruces R(CxR) y C(RxC), durante una estación de monta de 90 días: de mayo a julio, los meses de mayor precipitación.

La natalidad promedia, 74,3%, es superior al promedio nacional, estimado en 50%. La mayor y menor tasas de natalidad se presentaron en los apareamientos de Romo por F_1 CxR (82,9%) y en el de Cebú por Romo (52%). Debido a la baja natalidad de este grupo de apareamiento, las vacas Romo (ambos grupos 66,6%) fueron superadas por las Cebú (76,1%).

Según Castro y col. (1971), el menor comportamiento reproductivo de vacas Romo con toros Cebú obedeció a un problema de "discriminación racial". Los autores reportaron que en los lotes de apareamiento mixtos (vacas Cebú y Romo con toro Cebú) las dos razas no se mezclaban y dicha situación condujo a que las vacas Romo en celo tuvieran menor oportunidad de ser servidas por el toro Cebú.

La mortalidad (3,4%) de terneros de vacas Romo se considera normal, con valor similar (3%) a la de terneros de vacas cruzadas F_1; mientras que la de terneros Cebú (8,2%) fue cercana al valor medio reportado para el país (10%) y duplica el promedio no ponderado de los restantes grupos (3,4%). Debido a los mayores y menores índices de natalidad y mortalidad de los grupos con toro Romo, estos produjeron la mayor tasa de destete, 75,4%.

Crecimiento pre y posdestete de Romo

Los pesos promedios al nacer (PN) y destete (PD, ajustado a 270 días) de machos y hembras se presentan en el cuadro 3.

Los PN y PD se encuentran dentro del rango de valores reportados para otras razas criollas de Iberoamérica (Hernández, 1981; Plasse, 1983; Martínez, 1992). Los machos pesaron más al destete, aventajando a las hembras en 16,9 kg y no se presentó diferencia en el peso al nacer, 29,6 vs. 29,4 kg.

Crecimiento pre y posdestete de Romo y cruces

Simultáneamente con los estudios de caracterización fenotípica del Romo, se llevó a cabo, en el C.I. Turipaná, un plan de cruzamiento alterno con Cebú y uso de toros Charolais en apareamiento terminal con hembras F_1 Romo por Cebú (RxC) y Cebú por Romo (CxR). En el cuadro 4 se resumen los pesos (kg) y ganancias diarias (g/día) pre (GDND) y posdestete (GDD-18) y los correspondientes valores de heterosis individual (hi) y materna (hm), que destacan la habilidad combinatoria de las tres razas.

Los valores de hi oscilaron entre 4,7 y 22,7%, para PN y GDD-18, respectivamente; valores similares a los reportados en estudios con razas criollas Iberoamericanas y cebuínas (Hernández, 1981; Plasse, 1983; Martínez, 1992) y superiores a los reportados para cruces entre razas europeas (*Bos taurus*) y éstas con Gyr y Brahman (*Bos indicus*), en regiones templadas de Norte América (Frahm y Marshall, 1985; Trail y col., 1985).

Las vacas F_1 CxR y RxC produjeron las progenies más pesadas al nacimiento, destete y 18 meses de edad, lo que coincide con la literatura sobre la mayor productividad de vacas híbridas de criollo y cebú (Hernández, 1976, 1981; Martínez 1992; Plasse, 1983; Holgado y Rabasa, 1985). Los valores de hm fluctuaron entre -9.3 y 14.2% para GDD-18 y GDN-D, respectivamente; el valor negativo para GDD-18 estaría indicando que, una vez terminado el efecto materno, habría pérdida de adaptación, por mayor proporción de genes europeos de los trihíbridos con Charolais.

En el cuadro 5 se presenta el cálculo de producción de carne al destete por vaca expuesta a toro en el hato, basado en el porcentaje y peso de destete. La mayor producción de carne, por vaca expuesta (kg/vaca), se presentó en los grupos de retrocruces: toro Romo con vacas F_1 CxR (181,6 kg) y toro Cebú con vacas F_1 RxC (172,2 kg); superando ampliamente el promedio nacional, estimado en 88 kg/vaca.

La menor productividad de vacas Romo con toro Cebú (105,3 kg) obedeció a la menor tasa de natalidad (52%, cuadro 2), ocasionada por la conducta discriminatoria del Cebú; sin embargo, debido al excelente peso de destete del F_1 CxR (210,1 kg), la producción por vaca superó en 17,3 kg/vaca la estimada como promedio nacional.

Cuadro 3. Peso al nacimiento y destete de machos y hembras Romosinuano. Turipaná. 1959 a 1967. Adaptado de Hernández, B.G. (1970).

Detalle	Terneros nacidos	Peso nacimiento (kg)	Terneros destetados	Peso destete (kg)
Promedio general	2 341	29,5	1 510	174,0
Machos	1 127	29,6	755	182,4
Hembras	1 114	29,4	755	165,5

*Cuadro 4. Heterosis individual (hi) y materna (hm) y promedios de pesos al nacer (PN), destete (PD) y 18 meses (P18m) y ganancias diarias predestete (GDND) y posdestete (GDD-18) de Romo, Cebú y cruces con Charolis (Ch). Turipaná. 1970-1974. Adaptado de Hernández, B.G. (1976). * F_1 = RxC y CxR.*

Raza Toro	Raza Vaca	No.	PN (kg)	PD (kg)	P18m (kg)	GDN-D g/día	GDD-18 g/día
Romo	Romo	417	29,58	170,5	244,7	521	273
Romo	Cebú	148	29,38	214,1	305,8	684	335
Cebú	Romo	127	32,04	210,1	326,0	658	421
Cebú	Cebú	261	29,06	204,5	296,4	649	342
hi unidades			1,39	24,6	45,3	86	70
hi %			4,70	13,1	16,7	14,7	22,7
Ch	Romo	46	33,64	203,5	279,1	628	281
Ch	Cebú	7	29,09	224,9	326,1	724	362
Ch	F_1 *	50	34,09	242,6	319,3	772	262
Hm unidades			2,73	28,4	16,7	96	-59,5
hm %			8,70	13,2	5,5	14,2	-9,3

Cuadro 5. Producción de carne al destete por vaca expuesta a toro en el hato. Adaptado de Hernández, B.G. (1976, 1981).

Razas Toro Vaca	Destete %	Peso Destete (kg)	Produción carne (kg/vaca)
Romo Romo	78,5	170,5	133,8
Romo Cebú	74,6	214,1	159,7
Cebú Romo	50,1	210,1	105,3
Cebú Cebú	68,3	204,5	139,6
Romo F_1 CxR	79,9	227,3	181,6
Cebú F_1 RxC	75,5	228,1	172,2

Peso presacrificio y rendimiento en canal

Estudios de rendimiento carnicero, realizados en el C.I. Turipaná, Gómez y Acosta (1986) reportaron que los promedios de peso presacrificio (477 kg) y rendimiento en canal (56,7%) de novillos en pastoreo, Romo y sus cruces recíprocos F_1 con Cebú y F_2 (inter-sé), con 31 meses de edad media, fueron superiores a los valores estimados para el país: 48 meses, 400 kg y 55%, respectivamente. Los híbridos F_1 y F_2 superaron al Romo puro (420,3 kg, 52,6%) y el F_1 CxR (506 kg, 57.9%) aventajó en 29 kg y 1,2% el peso y rendimiento promedio de los restantes grupos cruzados y al Romo puro.

Figure 7. Ternera de tres años primipara.

Resumen y Conclusiones

Por sus características de adaptación a las condiciones climáticas y de manejo del trópico húmedo, reflejadas en excelentes parámetros de reproducción y supervivencia y por su gran aporte a la producción de híbridos de extraordinarios rasgos productivos, tanto de crecimiento como maternos, factores indispensables para desarrollar sistemas de producción ganaderos eficientes, sostenibles y competitivos en las condiciones del trópico cálido húmedo, no sólo de Colombia sino de Iberoamérica, es necesario realizar esfuerzos ingentes, tendientes a asegurar la conservación, desarrollo y uso racional y estratégico de la raza criolla colombiana Romosinuano.

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Genetic resistance to endoparasites in sheep and goats. A review of genetic resistance to gastrointestinal nematode parasites in sheep and goats in the tropics and evidence for resistance in some sheep and goat breeds in sub-humid coastal Kenya

R.L. Baker

International Livestock Research Institute (ILRI)
*P.O. Box 30709, **Nairobi**, Kenya*

Summary

The evidence for both between- and within- breed genetic variation for resistance to gastrointestinal (GI) nematode parasites is reviewed. It is concluded that much of the published research on breed characterisation for resistance suffers from poor experimental design. Prior to the initiation of a 6-year study that has just been completed in coastal Kenya there were no estimates of within-breed genetic variation (i.e. heritabilities) of resistance in sheep or goats in the tropics. This study has confirmed that Red Maasai sheep and Small East African (SEA) goats are more resistant to GI parasites (predominantly *Haemonchus contortus*) than Dorper sheep and Galla goats. Heritability estimates for logarithm transformed faecal egg counts (an indicator of resistance) in 8-month-old lambs was 0.18±0.08 for all lambs, but higher in the susceptible Dorper-sired lambs (0.35±0.16) than in the resistant Red Maasai-sired lambs (0.06±0.07). This difference in heritability suggests that many centuries of natural selection have fixed most of the genes for resistance in the Red Maasai sheep. The resistant Red Maasai sheep and SEA goats were two to three times more productive than the susceptible Dorper sheep and Galla goats in the sub-humid coastal Kenya environment.

Resumen

Se presenta una revisión de la variación genética entre y dentro de las razas para la resistencia a los nematodos gastrointestinales (GI). Se concluye que mucha de la investigación publicada sobre la caracterización de las razas para la resistencia carecen de diseño experimental. Antes de iniciar el estudio de 6 años que acaba de concluirse en la costa del Kenya, no se encontraban estimaciones acerca de la variación genética dentro de la raza (por ejemplo la heredabilidad) para la resistencia en ovinos y caprinos en zonas del trópico. Este estudio ha confirmado que la raza ovina Red Maasai y la cabra Small East Africa (SEA) son más resistentes a los parasitos GI (sobre todo a *Haemonchus contortus*) que la oveja Dorper y la cabra Galla. La estimación de la heredabilidad del logaritmo transformado del número de huevos fecales (que es un indicador de resistencia) en corderos de 8 meses era de 0,18±0,8 para todos los corderos, pero era superior en los machos susceptibles de raza Dorper (0,35±0,16) en comparación con los corderos resistentes de raza Red Maasai (0,06±0,07). Esta diferencia en la heredabilidad sugiere que muchos siglos de selección natural han fijado muchos de los genes para la resistencia en la oveja Red Maasai. La raza Red Maasai y la cabra SEA eran de dos a tres veces más productivas que la oveja susceptible de raza Dorper y que la cabra Galla en un medio como la zona subhumida de la costa del Kenya.

Key words: *Sheep, goats, genetic resistance, gastrointestinal parasites,* Haemonchus*, Kenya, Dorper sheep, Galla goats.*

Introduction

Helminths constitute one of the most important constraints to ruminant livestock production in the tropics (Fabyi, 1987). Widespread infection with internal parasites in grazing animals, associated production losses, anthelmintic costs and death of infected animals are some of the major concerns. Current control methods focus on reducing contamination of pastures through anthelmintic treatment and/or controlled grazing. In the tropics, these methods are limited by the high costs of anthelmintics, their uncertain availability, increasing frequency of drug resistance (Waller, 1997) and limited scope in many communal farming systems for controlled grazing. An attractive sustainable solution is to utilise host genetic resistance for disease control.

There is a large and diverse range of indigenous sheep and goat breeds/populations in the tropics, some of which appear to have unique genetic ability to resist or tolerate diseases (Baker, 1995). This paper reviews the limited data available on both between- and within- breed genetic variation for resistance to helminthosis in sheep and goats in the tropics. Some of the results of an ILRI research project on genetics of resistance to gastrointestinal nematodes in small ruminants in sub-Saharan Africa are also presented.

Criteria of Resistance, Resilience or Tolerance

Clunies-Ross (1932) was the first to recognise the need for the distinction between "resistance to infection" and "resistance to the effects of infestation". There is some confusion in the literature about how to define these effects, but the following definitions are commonly used (Albers *et al.*, 1987; ILCA, 1991).

Resistance, defined as the initiation and maintenance of responses provoked in the host to suppress the establishment of parasites and/or eliminate parasite load.

Resilience or Tolerance, defined as the ability of the host to survive and be productive in the face of parasite challenge.

For a number of reasons measurement of resistance appears more useful than measurement of resilience or tolerance. For example, tolerance or resilience does not imply control of the parasite and therefore contamination of pasture will increase because faecal egg output of the animals is not being reduced. With resistant animals, however, the contamination of pasture by infective larvae gradually decreases (Windon, 1990). However, it can also be noted that if parasites can adapt to anthelmintics, they can probably also adapt to resistant hosts. It has therefore been suggested that until it is known what occurs in parasite adaptation, it is better to select for resilience because there is no pressure being exerted on the parasite for genetic adaptation. Research to date suggests that genetic adaptation of parasites to resistant hosts may not be a major problem (Windon, 1991; Barger and Sutherst, 1991; Woolaston *et al*., 1992).

Parasites Species and Mode of Infection

Both natural pasture challenge and artificial (experimental) infections have been used in assessing resistance to endoparasites. There is a wide diversity of internal parasites and under natural challenge ruminants usually harbour more than one species (Gruner, 1991). These include the three major orders (Nematoda, Cestoda and Trematoda) and a range of genera within orders (Hansen and Perry, 1994). The life cycle, population biology and pathogenecity of the different species are not the same, but in most cases are relatively well known.

Nearly all the research to date on resistance to endoparasites has concentrated on the Nematodes and particularly the Trichostrongyles (e.g. *Haemonchus, Ostertagia*, *Trichostrongylus* and *Nematodirus* spp). There have been some reports in sheep of breeds resistant to *Fasciola hepatica* (Boyce *et al*., 1987) and *Fasciola gigantica* (Wiedosari and Copeman, 1990; Roberts *et al.*, 1997a). While this review will concentrate on resistance to GI nematodes there is scope for further research on host genetic resistance to Trematodes (flukes), especially given the recent report of a major gene controlling resistance to *Fasciola gigantica* in Indonesian Thin Tail sheep (Roberts *et al.*, 1997b).

In order to obtain meaningful results with natural infection it is first important to assess which are the most economically important parasites in any particular agro-climatic zone. When there is a diversity of parasites present then natural infection is preferred, particularly to assess breed differences. In assessing within breed genetic variation to obtain heritability and genetic correlation estimates then artificial infection is often preferred in experimental studies (Woolaston *et al.,* 1991; Woolaston and Eady, 1995), but natural infection is also commonly used both in experimental studies and commercial breeding programmes (Morris *et al.,* 1995). Usually artificial infection is with a single parasite species (e.g. *Haemonchus contortus* or *Trichostrongylus colubriformis*), although sometimes a mixed infection is given. When artificial infection is used, it is important to assess how this relates to resistance under natural pasture challenge. There is encouraging evidence that the genetic correlation between natural and artificial infections with GI nematodes in sheep is high and positive (Gray *et al*., 1991; Woolaston and Eady, 1995; Bouix *et al*., 1995).

Piper and Barger (1988) noted that artificial infection excludes any expression of genetic resistance due to the grazing behaviour of the host. They suggested that selection for resistance based on natural infection is to be preferred, as it makes fewer assumptions about the basis of host resistance. However, in those climates where there is marked variation between years or seasons in intensity of larval challenge on pasture, artificial infection may need to be included in conjunction with natural infection.

Parameters to Be Measured

The most common trait measured to predict resistance to GI nematodes has been faecal egg count (FEC). Reservations have been expressed about the use of FEC as a measure of resistance to internal parasites (Dargie, 1982; Gruner, 1991). It has been noted that FEC is not always closely related to worm burdens and that FEC is affected by an array of host-parasite relationships such as level of host immunity, age of host, species of parasite, stage of infection, parturition and accuracy of faecal egg counting. Despite these reservations, a large volume of experimental evidence shows that FEC can be used to assess the resistance/susceptibility status within and between breeds and strains of sheep (Eady, 1995) and it is both a repeatable and heritable trait. While FEC is a useful indicator trait of resistance to GI nematodes, it is also a valuable trait in its own right as a measure of the degree to which an animal is contaminating pastures with worm eggs.

Packed red cell volume (PCV), a measure of anaemia, is another very useful indicator of host resistance to endoparasites, particularly for blood-sucking parasites such as *Haemonchus contortus* (Albers *et al*., 1987).

Worm counts are the best measure of resistance to GI nematodes but involve slaughtering the animal. Worm counts have been quite commonly measured in breed characterisation studies. However, worm counts as a measure of resistance cannot easily be used in within breed selection studies because potential candidates for selection have to be sacrificed to measure the worm counts. In theory it would be possible to use some form of family selection to utilise worm counts in selection programmes, but the cost of doing this is probably prohibitive. At least in young sheep less than one year of age, there is good evidence for a strong positive phenotypic correlation between FEC and worm burdens (McKenna, 1981; Morris *et al.,* 1995).

The immunological mechanisms and parameters which reflect the underlying genetic resistance could potentially be used as phenotypic markers of resistance (Douch *et al.*, 1996). However, to date, no immunological parameters have been identified that are better predictors of resistance than FEC.

Resilience is a more difficult trait to measure, because to obtain a measure of how much of an animal's production is affected by the parasites, it is necessary to record production with and without a challenge infection (Albers *et al.*, 1987). An alternative method of measuring resilience which has been investigated in sheep, is based on anthelmintic treatment requirements (e.g. number of treatments in young lambs) while grazing infective pasture (Bisset *et al.,* 1994; Morris *et al*., 1995; Bisset and Morris, 1996).

Genetic Variation for Disease Resistance

There is ample evidence that genetic variation for disease resistance in domestic animals exists (Owen and Axford, 1991). Genetic resistance to the important infectious diseases of domestic livestock is usually found to follow polygenic inheritance, as do the production traits. In this situation we are interested in estimating the magnitude of genetic variation both between breeds or strains and within breeds and ultimately utilising this genetic variation for resistance in breeding programmes (Woolaston and Baker, 1996).

Breed Variation

There have been many reports since the mid-1930's of variation among breeds of sheep in resistance to internal parasites, particularly to *Haemonchus contortus, Ostertagia spp* and *Trichostrongylus spp*. Gray (1991) summarised 23 publications on this subject and this was expanded to 34 studies in a review by Baker *et al.*(1992). A number of indigenous 'unimproved' breeds of sheep in Africa (Red Maasai, Djallonke and Sabi), the Caribbean (St. Croix and Barbados Blackbelly), North America (Florida Native, Louisiana Native and Navajo) and India (Garole) appear to be relatively resistant or tolerant to GI nematodes. While there is less evidence for resistance among goat breeds, again the indigenous breeds (e.g. the Small East African and the West African Dwarf) appear to be more resistant (Baker *et al*., 1992, 1998a; Baker, 1995).

Nearly all the studies reviewed by Gray (1991), Baker *et al*. (1992) and Gray *et al*. (1995) are characterised by poor experimental design, both in terms of the numbers of animals of each breed tested, and the lack of information on how the breeds were sampled (Woolaston, 1997). In addition, very few of the studies took account of variation among sires within breeds. The magnitude of the between-sire differences can be of the same order as the largest of the between breed differences (Gray *et al*., 1987). Consequently, many of the breed differences reported could just reflect a single sire effect and hence should be interpreted cautiously.

While many of the publications on genetic variation for resistance in disease can be criticised in terms of experimental design, it is reassuring to note that some breeds have been identified as resistant in a number of independent studies. This applies particularly to the Florida Native, St. Croix and Red Maasai sheep breeds, and it is very likely these breeds have some real genetic resistance to internal parasites. It is worthy of note that the St. Croix sheep originated from West Africa and are probably related to the Djallonke sheep (Bradford and Fitzhugh, 1983), which are believed to be relatively resistant to endoparasites (Osinowo and Abubakar, 1988; Smith, 1988). Most of the breeds identified as being relatively resistant are native or 'unimproved' breeds. This presumably reflects the fact that these breeds have been under natural selection for a long time with little or no treatment with anthelmintic drugs.

Heritabilities

In small ruminants most of the heritability estimates of resistance to endoparasites (assessed in terms of either FEC or PCV) are from Merino or Romney sheep in Australasia (Gray and Woolaston, 1991; Gray *et al*.,1995). The average heritability for a single FEC measurement from estimates reviewed by Baker *et al*., (1992) was 0.32, while the average estimates for PCV was 0.35. The heritability of the mean of several (2 to 3) egg counts recorded in different infections increased to about 0.4 to 0.5. Heritabilities were similar for different modes of infection (natural and experimental), and for infections with different parasite genera (both single genus infections and mixed infections). In Africa, the few estimates of heritabilities and repeatabilities of resistance to endoparasites in sheep and goats are similar to those found in Australasia (Baker *et al*., 1992, 1994a, 1998b; Baker, 1995). There are no estimates of heritability of resilience to gastrointestinal nematodes in sheep or goats in the tropics but Australasian estimates are all low and range from 0.06 to 0.14 (Albers *et al.*, 1987; Bisset *et al*., 1994).

ILRI's Research on Endoparasite Resistance

In 1991, the International Livestock Centre for Africa (ILCA - now ILRI) initiated a Pan-African research project to investigate more comprehensively than previous studies both between- and within-breed genetic resistance to GI nematode parasites in some indigenous breeds of sheep and goats in Kenya, Ethiopia, Senegal and Zimbabwe (ILCA, 1991). The research in Kenya and Ethiopia was completed in 1997. The research with sheep and goats in Kenya is reported here as an illustration of the type of experimental design employed and the results obtained (Baker *et al.,* 1994a, 1998a, 1998b).

Kenya - Sheep

Experimental design

This study was carried out at Diani Estate of Baobab Farms, 20 km south of Mombasa in the sub-humid coastal region of Kenya. In 1991, Dorper and Red Maasai x Dorper (F_1) ewes, and in 1992 and in subsequent years Dorper, F_1 and Red Maasai ewes were single—sire mated to 12 Red Maasai (Figure 1) and 12 Dorper (Figure 2) rams each year in a complete diallel to produce the six lamb genotypes shown in Table 1.

At least half of both the Dorper and Red Maasai rams used each year were replaced by new rams the next year. A total of 41 Dorper and 35 Red Maasai rams were used. The rams were obtained from a wide range of sources and districts in Kenya to ensure representative samples of each breed.

The ewes were weighed six times during the reproductive cycle: at mating; three

Table 1. Number of single-born lambs alive at birth by genotype in 1991-96 at Diani Estate, Mombasa,Kenya.

Lamb breed (Sire breed x Dam breed)	Year of birth						
	1991	1992	1993	1994	1995	1996	Total
Dorper x Dorper (D)	98	66	55	30	39	30	318
Dorper x (RM x D)	85	76	93	71	67	35	427
Dorper x RM		7	38	25	27	27	124
Red Maasai x D	85	58	57	14	15	9	238
Red Maasai x (RM x D)	99	81	95	61	68	66	470
Red Maasai x Red Maasai (RM)		8	34	48	64	64	218
Total	367	296	372	249	280	231	1795

Figure 1. Red Maasai sheep.

Figure 2. Dorper sheep.

months after mating; two weeks before lambing; and one, two and three months after lambing. Blood and faecal samples were collected from all ewes at each weighing. Blood was taken to determine packed cell volume (PCV), to measure anaemia, and was also examined for trypanosomes. Faecal egg counts (FEC), a measure of GI nematode infestation, were taken and faecal samples, bulked by breed, were cultured and parasite larvae present were identified. Ewes found to have a FEC greater than 4 000 egg per gram (epg) or a PCV less than 15% at any measurement time were treated with an anthelmintic drug.

Lambs were weighed as close to birth as possible, usually within 24 hours, and then every two weeks up to weaning at three months of age. PCV and FEC were recorded on all lambs at one and two months of age and if individual lambs had a FEC greater than 2 000 epg or a PCV less than 20% at these samplings they were treated with an anthelmintic drug. All the lambs were treated with an anthelmintic at weaning (90 days of age). They were then grazed on pasture until a monitor group of about 50 lambs, from which samples were taken every week, reached a FEC averaging about 2 000 epg. All the lambs were then weighed and faeces and blood samples were taken on two consecutive days. The lambs were then all treated with an anthelmintic. This procedure was repeated until the lambs reached a year of age, which usually involved five or six sampling times (Figure 3). No lambs were individually drenched at any of the post-weaning sampling times.

The breed effects were derived from least-squares analyses of variance (Harvey, 1990). The model fitted included, when significant, the fixed effects of year of birth, breed, sex, age of dam, lamb age as a linear covariate and any significant first-order interactions. Only single-born lambs were analysed as there were very few twin births, and most of the twin-born lambs died before weaning. Faecal egg counts were logarithm transformed ($\log_{10}$(FEC+25)) to normalise the variance and then presented in the results as the anti-log (i.e. the geometric mean-GFEC).

Heritabilities were estimated by Average Information Restricted Likelihood (AIREML) using an animal model (Johnson and Thompson, 1995). The AIREML animal model included all significant fixed effects identified in the least squares analyses and in all analyses breed-cross (six classes) and year of birth (1991-96) were included in the model. Genetic variance was partitioned into a direct additive genetic component (h^2_a) and the additive genetic maternal component (h^2_m). In addition an AIREML sire model (paternal half sib analysis) was used to estimate heritabilities (h^2_s). Heritabilities were also estimated using the AIREML sire model for lambs sired by Red Maasai and Dorper rams separately and in this case the breed-cross effect just included 3 classes. All breed effects and heritabilities for lambs are based on the average of the records taken on the two consecutive sampling days.

Results

Differences among the breeds and crosses for weaning weight, PCV, GFEC and mortality for lambs at weaning and post-weaning are shown in Table 2 and Figure 4. Faecal cultures at these times showed that 66% of the larvae were *Haemonchus contortus*, 30% *Trichostronglus spp* and 4% *Oesophagostomum spp*.

The results show that Red Maasai lambs are more resistant to endoparasites than Dorpers in the subhumid zone of coastal Kenya. Red Maasai lambs have significantly lower GFEC, higher PCV and lower lamb mortality than Dorper lambs. This breed difference is already apparent in 2-month-old lambs for PCV and at weaning (3 months of age) for GFEC (Figure 4). There is also an additive genetic breed effect in the crossbred lambs for resistance (i.e. with increasing proportion of Red Maasai in the crossbred, Table 2), but no evidence for heterosis for liveweight, GFEC or PCV. The difference among breed groups in mortality is dramatic and post-mortem results show that about 50-60% of the post-weaning mortality is due to haemonchosis. The differential mortality

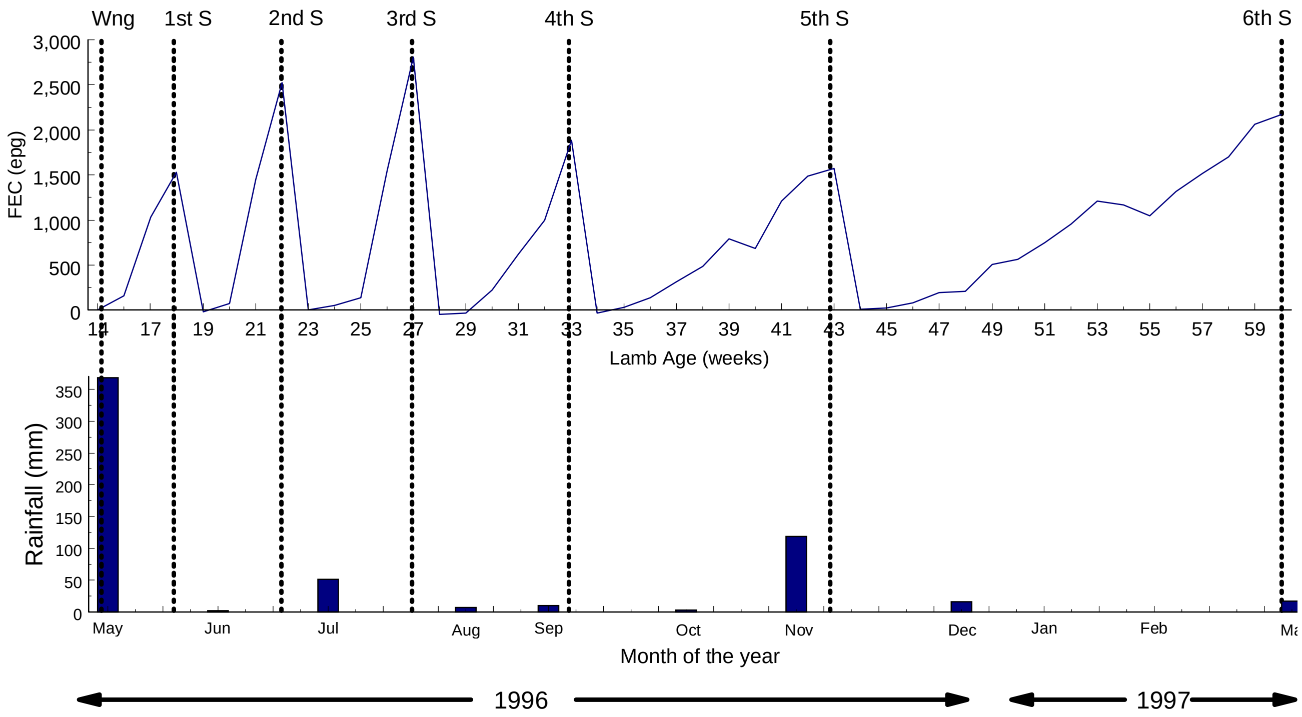

Figure 3. Pattern of change in faecal egg count (FEC) in lambs born in 1996 and the different sampling times (S) when the threshold FEC was reached in relation to the monthly rainfall.

conducted in the Kenya highlands (Preston and Allonby, 1978, 1979; Bain *et al*., 1993; Mugambi *et al*., 1996). In addition, Red Maasai ewes have lower FEC and higher PCV over the lambing-lactation period (the peri-parturient rise) than Dorper ewes (Baker *et al*., 1994b; 1998b).

In addition to confirming genetic variation in resistance to endoparasites among breeds and crosses, this study is providing some reliable evidence of genetic variation within these breeds (Table 3). For all live weights from birth to one year of age the additive genetic maternal heritability (h^2_m) was significant, while the direct additive heritability (h^2_a) was small and non-significant among breed-crosses also means that the least squares means for breed-cross for FEC and PCV (and possibly live weights as well) are biased. The differences among the breeds and crosses for FEC and PCV in Table 2 and Figure 4 are biased downwards because the lambs that died from haemonchosis consistently had high FEC and low PCV. The statistical solution to this problem is not a trivial issue and research is currently ongoing to attempt to resolve it by developing mixed effect nonlinear models for repeated measures employing likelihood based and Bayesian procedures.

The relative resistance of the Red Maasai lambs confirms earlier reports from research

Table 2. Least squares means (LSM) by breed group for weaning weight (WWT, kg), packed cell volume (PCV, %), the geometric mean of faecal egg count (GFEC, eggs per gram) and mortality (MORT, %).

	Weaning (3 mo)				Post-Weaning		
Lamb breed[1] (Sire Bd x Dam Bd)	WWT	PCV	GFEC	MORT (Bth-Wn)	PCV (6 mo)	GFEC (6 mo)	MORT (Wn-Yg)
D x D	11.2	23.5	1412	30.0	21.9	2818	39.2
D x (RM x D)	11.1	25.2	1174	22.4	21.8	2238	31.4
D x RM	10.7	25.7	1230	18.4	22.2	2511	29.8
RM x D	10.9	25.6	1023	20.4	23.5	2290	27.2
RM x (RM x D)	10.9	26.6	1096	16.7	24.0	2089	14.3
RM x RM	10.1	27.4	1174	10.3	24.3	1949	18.4
Total No.	1435	1411	1142	1779	1165	1165	1435
Overall LSM	10.8	25.7	1779 (3.07)[3]	19.7	22.9	2291 (3.36)[3]	26.7
Residual S. D.	2.2	5.5	(0.56)[3]	37.8	3.7	(0.34)[3]	38.0
CV[2] (%)	20.4	21.4	18.2[3]	191.9	16.1	9.9[3]	142.3

[1]D = Dorper, RM = Red Maasai.

[2]CV = Coefficient of variation (Residual standard deviation/LSM).

[3]*Figures in brackets are log $_{10}$(Fec+25) values which is the unit of analysis and the CV is based on these values.*

at weaning (0.05±0.04), but increased to 0.24±0.09 for YWT. The h^2_m was not significant for PCV, LFEC or lamb mortality. The paternal half sib heritability estimate (h^2_s) for pre-weaning mortality was non-significant (0.03±0.03), but was significant for post-weaning mortality (0.10±0.05). Heritabilities (h2a and h2m) for both PCV and LFEC were small and non-significant at weaning. The h^2_s for LFEC was moderate and significant in 8-month old lambs (0.18±0.08), but higher in the susceptible Dorper-sired lambs (0.35±0.16) than the resistant Red Maasai-sired lambs (0.06±0.07). This suggests that, after many centuries of natural selection under endoparasite challenge, the Red Maasai sheep have become fixed for some of the important genes for resistance. Heritabilities for live weights, PCV and mortality were also estimated separately for Red Maasai-sired lambs and Dorper-sired rams but they were not significantly different.

An assessment has been made of the flock productivity of Dorper and Red Maasai sheep in this coastal Kenyan site (Table 4). The combined effect of a higher lambing rate, lower lamb mortality and similar yearling live weights results in an approximately three-fold increase in the number of yearling sheep for sale and the weight of yearling sheep for sale in a Red Maasai *vs* a Dorper flock. There is therefore a clear economic advantage for farming the more resistant breed in the coastal Kenya sub-humid environment. These findings have resulted in FAO funding the development of a pilot nucleus breeding scheme for Red Maasai sheep in coastal Kenya. The ultimate aim of this breeding scheme is to make Red Maasai rams more readily available to smallholder farmers in the coastal region of Kenya.

Kenya – Goats

The Galla and the Small East African (SEA) goats breeds (Figures 5 and 6) are also being evaluated for their resistance to endoparasites at Diani Estate using the same experimental protocol as for the sheep. In this case the

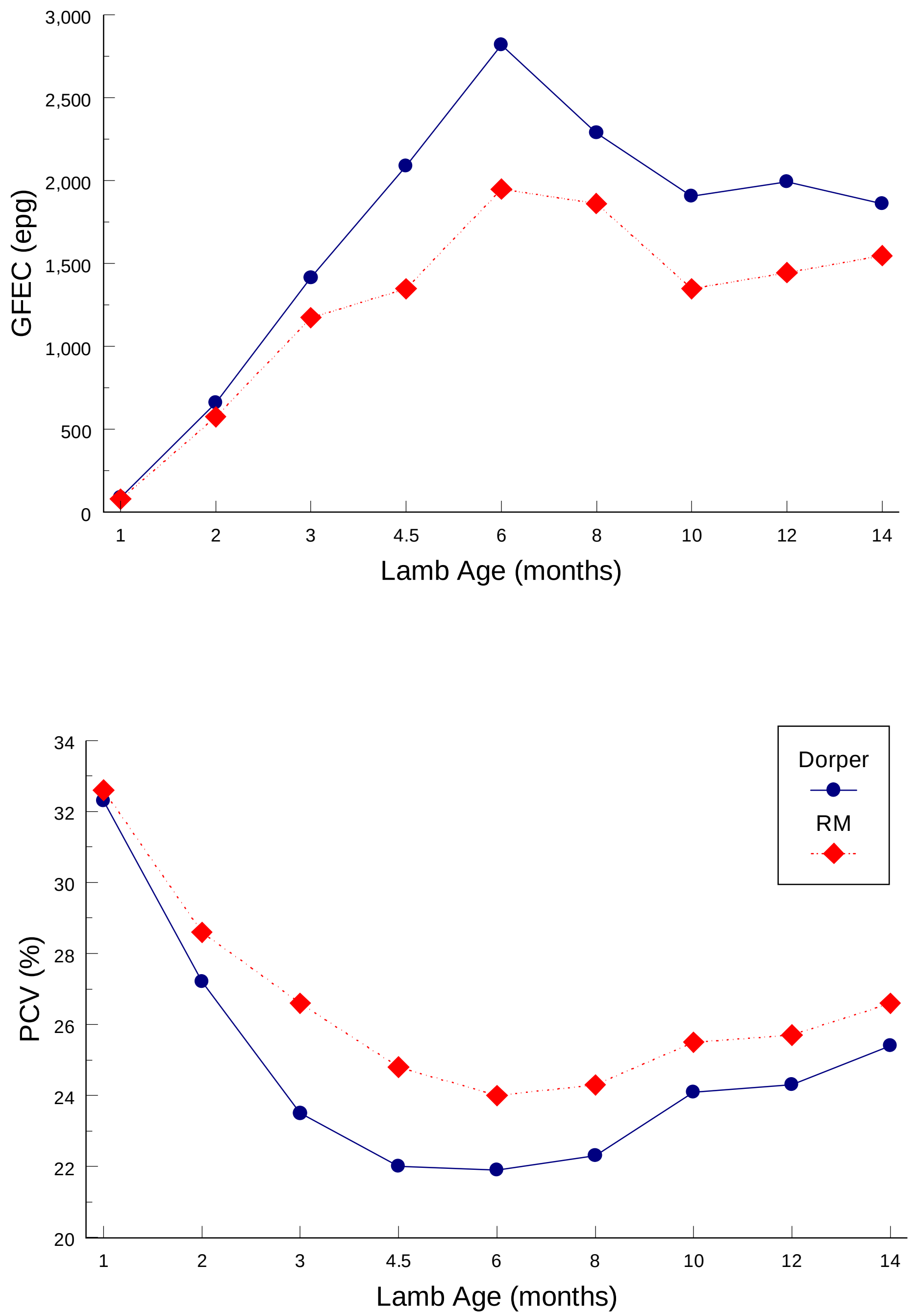

Figure 4. The geometric mean of faecal egg count (GFEC) and packed cell volume (PCV) for Red Maasai and Dorper lambs from 1 to 14 months of age.

Table 3. Heritability estimates for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), packed cell volume (PCV), logarithm transformed faecal egg count (LFEC) and lamb mortality.

		Animal model[1]				Sire model
Trait	No. records	No. dams	No. sires	$h^2_a \pm$ se	$h^2_m \pm$ se	$h^2_s \pm$ se
BWT	1 792	724	76	0.10±.04	0.37±.03	0.10±.04
WWT	1 435	659	76	0.05±.04	0.28±.04	0.03±.04
YWT	970	530	75	0.24±.09	0.18±.05	0.24±.09
PCV-Wng	1 411	652	76	0.01±.03	0.05±.03	0.01±.03
PCV- 8mo	1 080	558	75	0.07±.06	0.02±.04	0.08±.06
LFEC-Wng	1 142	591	76	0.01±.04	0.00±.04	0.04±.05
LFEC- 8mo	1 080	558	75	0.10±.06	0.00±.04	0.18±.08
Lamb mortality						
Bth-Wng	1 779	720	76	0.02±.03	0.04±.03	0.03±.03
Wng-Ylg	1 437	659	76	0.09±.05	0.00±.03	0.10±.05

[1]h^2_a = additive direct heritability; h^2_m = additive maternal heritability.

Table 4. Productivity of flocks of Dorper and Red Maasai sheep and Galla and Small East African (S.E.A.) goats at Diani Estate, Mombasa, Kenya.

Trait	Dorper	Red Maasai	Galla	S.E.A
No. of ewes/does mated	853	457	371	359
Ewe/doe live weight (kg)	30	26	35	28
Ewes lambing/ewes mated (%)	66.4	75.1	47.4	75.2
Prolificacy (%) (lambs born/ewes lambing)	102.0	101.9	116.5	129.3
Lamb/Kid mortality (Bth-Ylng, %)	66	28	45	35
Yearling live weight (kg)	19.7	18.4	18.5	15.5
Offtake (1 yr)[1]				
No. of sheep/goats	11	35	15	43
Total live weight (kg)	217	644	278	667

[1]Offtake based on a 100 ewe or doe flock with a 20% female replacement rate and all male progeny and non-replacement females alive at one year of age making up the offtake. The Dorper and Galla flocks are not sustainable at this replacement rate in this environment.

Figure 5. Small East African goats.

Figure 6. Galla goats.

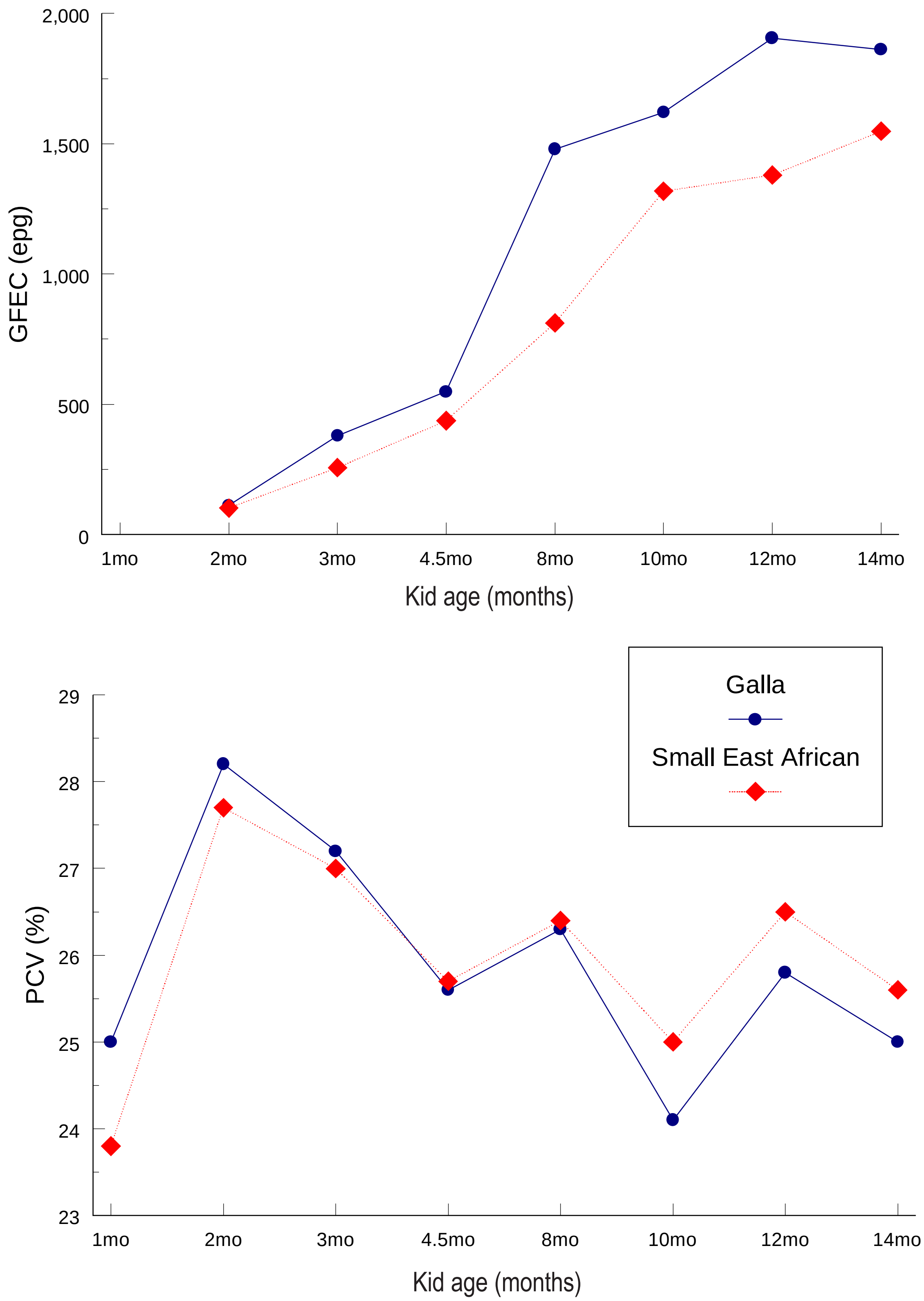

Figure 7. The geometric mean of faecal egg count (GFEC) and packed cell volume (PCV) for Galla and Small East African kids from 1 to 14 months of age.

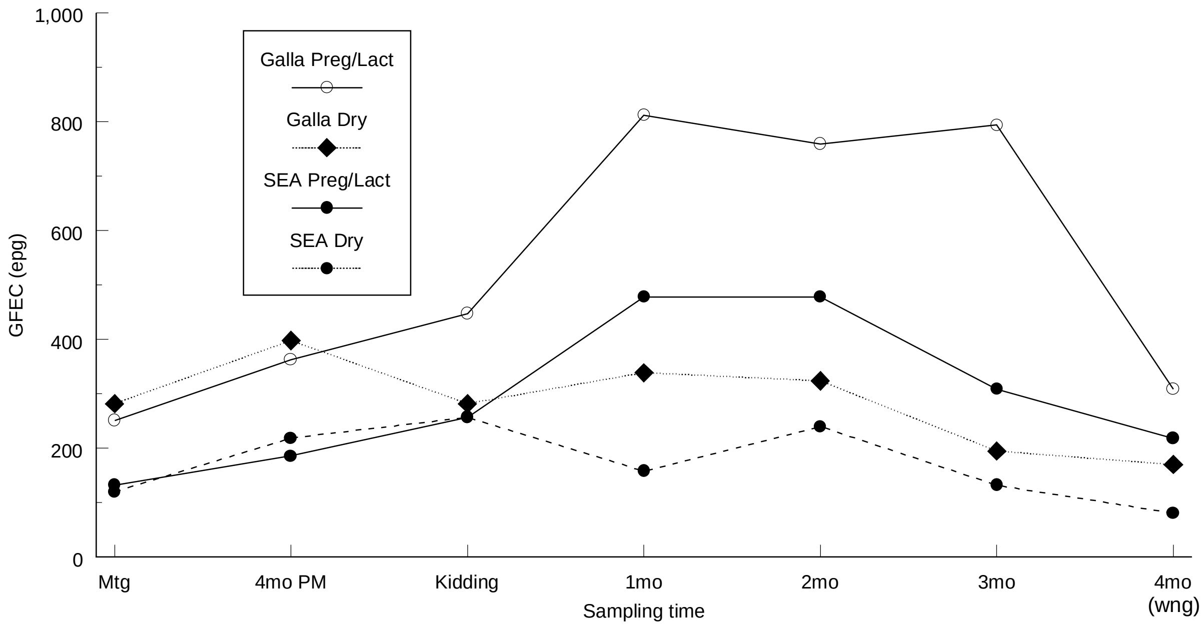

Figure 8. The geometric mean of faecal egg count (GFEC) for pregnant/lactating and dry (non-pregnant) Galla and Small East African (SEA) does.

experimental design is a comparison of the two breeds and not a diallel design as for the sheep experiment. Five crops of kids were produced between 1992 and 1996 and a total of 553 kids were born (204 Galla and 349 SEA). These were the progeny of 18 Galla and 17 SEA bucks. The statistical analyses were similar to those for the sheep except now litter size was included in the model as a fixed effect.

The SEA kids are more resistant to GI nematode parasites than Galla kids as shown by lower FEC in SEA kids post-weaning and a significantly higher PCV in SEA kids. The higher PCV in the resistant SEA kids occurs when they are 10-12 months of age (Figure 7), which is a different response than that observed in the lambs where the breed difference in PCV is apparent by 2 months of age. The breed difference in kid mortality is not as dramatic as in the lambs, but the resistant SEA kids had a significantly lower mortality from birth to one year of age than the Galla kids (35.4% *vs* 44.6%, respectively). The breed difference in resistance was also apparent in the does (Baker *et al.,* 1998a) and the difference in FEC was particularly marked in pregnant/lactating does over the peri-parturient period (Figure 8). These results are consistent with those reported by Shavulimo *et al*. (1988) but not consistent with those reported in a small study by Preston and Allonby (1978) where Saanen goats were more resistant than Galla and SEA goats.

This goat data set is not large enough to allow reliable heritabilities to be estimated. The heritabilities (h^2_a) of PCV and FEC at weaning were 0.11±0.11 and 0.11±0.10, respectively. Utilising the first three post weaning measurements in repeated measures analyses, the heritabilities (h^2_a) for 6-month old kids were 0.18±0.06 for PCV and 0.03±0.03 for FEC.

There is a marked difference in reproductive performance between these two breeds with overall reproduction (kids weaned/does mated) being 79% for SEA and 40% for the Galla. This results in a clear advantage in flock productivity for the SEA *vs* the Galla (Table 4). It is also interesting to note that the productivity, measured by weight of lambs or kids available for sale, of the resistant Red Maasai sheep and the resistant SEA goats were very similar in this environment (644 kg *vs* 667 kg, respectively).

Future Plans

The first phase of this research project involving quantifying between- and within-breed genetic resistance of some indigenous breeds of sheep and goats in sub-Saharan Africa is now nearing completion. Similar characterisation research will be carried out in other tropical regions of the world. For example, new research in Southeast Asia (initially in the Philippines and Indonesia) will begin in 1999.

The second phase of this study (1998-2002) will investigate parasitological, immunological and genetic mechanisms of resistance; develop and test sustainable, integrated endoparasite control strategies; identify genetic (DNA) markers for resistance; and develop breeding strategies for resistance to endoparasites in tropical environments. Research has begun in Kenya using F_1 rams from resistant and susceptible breeds (i.e. Red Maasai x Dorper) to produce large double backcross resource families to search for markers and ultimately genes controlling resistance to GI nematode parasites (particularly *Haemonchus contortus*).

Acknowledgements

The results from the ILRI research project on genetic resistance to endoparasites in small ruminants which are briefly summarised here depended on the collaborative efforts of many people. I would like to acknowledge in particular W. Thorpe, J.O. Audho, E. Aduda (ILRI, Nairobi, Kenya), D. M. Mwamachi (Kenya Agricultural Research Institute) and R. Haller (Baobab Farm, Mombasa, Kenya). This is ILRI Publication No. 98027.

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The Ponies of the Giara highland

M. Dattilo

Centre for Phenomenological Studies, Dept. of Animal Production, University of Sassari
Piazza Conte di Moriana s.n.c., 07100 ***Sassari****, Italy*

Summary

The Giara pony is a less known, equine breed of small stature, typical of the island of Sardinia. It draws its denomination from the highland of the Giara, where it lives in the wild.

The ponies appeared in Sardinia approximately in the VII century B. C. Recent research, carried out on haemoglobin polymorphism, underlined some analogies with the Arabic horses of North-Africa.

These ponies, have a dolyichomorphic-type constitution with long, naked and resistant legs. In the past they were used for agricultural work, however later, with the increase of mechanisation, they returned to the Giara highland where they became feral.

The Giara ponies, in the light of recent scientific research, possess not only an inestimable genetic patrimony but they also represent a large source of interest for the equestrian sport, and, above all, for children's riding therapy.

The author underlines, finally, that the principal material of this article has been outlined in a symposium held at the University of Sassari 18/11/1997, entitled: "Phenomenology of the environment: psycho-social and zoo-anthropological perspectives".

Resumen

El poco conocido pony Giara pertenece a una raza equina de pequeña estatura, típica de la isla de Cerdeña. Su nombre le viene del altiplano de Giara donde vive en estado silvestre.

Los ponys aparecen en Cerdeña aproximadamente en el siglo VII a.C. Investigaciones recientes llevadas a cabo sobre el polimorfismo en la hemoglobina, indican algunas semejanzas con el caballo Arabe de Africa del Norte.

Estos ponys tienen una constitución dolicomórfica con cuello largo y patas resistentes. En el pasado se utilizaban para el trabajo de campo, sin embargo más tarde, con el aumento de la mecanización, volvieron a la zona del altiplano de Giara donde se volvieron de nuevos silvestres.

Los ponys Giara, a la luz de recientes investigaciones científicas, poseen no sólo un patrimonio genético inestimable, sino que también representan una fuente importante de recursos para el deporte ecuestre y, sobre todo, para la terapia infantil.

El autor subraya que los temas principales de este artículo han sido ilustrados en un symposium que tuvo lugar en la universidad de Sassari el 18 de noviembre 1997, bajo el título: Fenomenología del medio: prospectivas psicosociales y zooantropológicas.

Key words*: Riding therapy, Horse psychology, Sardinia, Characteristics.*

Introduction

The ponies live in the wild on the Giara plateau. The Giara is a basaltic plateau of coarsely triangular form in the Southern-Centre of Sardinia (between the Marmilla and the Sarcidano), approximately

42 km^2 and 550 m above sea level (Figure 1). It occupies around 4 600 hectares, half of which really are the highland, the other half being a small, undulated and characteristically rural area around the highland itself (Genoni, Gesturi, Tuili, etc.). The unemployment level is very high and constitutes about 25% of the active population.

The word Giara (*Yara* in Sardinian) derives from the Latin *Glarea*, that means gravel. It can be recognised by two cone-shaped reliefs, that are what remains of two volcanoes that were erupting until two million years ago; pouring out the lava that today constitutes the basaltic matrix of the ground. There are natural basins called *Paulise*, which collect rain water however the water cannot flow out and in drought periods, water is lacking and the ponies suffer terribly from thirst.

The agricultural land, based on volcanic (basaltic) rocks rich in Ca, Mg, Fe, highly diffused in Sardinia, is present almost everywhere with its black colour, shallow depth and scarce fertility. In the past, the tall stem plants (cork oak, ilex, wild olive tree, etc.), were predominant but subsequently they have been partially replaced (because of human impact and fires) by shrub species (*Cistaceae, Arbutus unedo, Myrtus communis*, etc.; wild orchids in spring). The pasture, naturally scarce, is exploited by the other domestic animals and it is not abundant enough to feed the ponies. However, the ponies hoofs are sufficiently elastic and adjust well, allowing the ponies an extraordinary ability of movement and resistance in a unstony dry ground . The distinctive environment of the Giara horses is shown in figure 2.

Pony Breeds

In the dreams of every child there is always a pony upon which to gallop and challenge danger. Such dreams do not often come true. The pony is a horse of small stature that does not exceed 140-145 cm height at withers.

There are different pony clubs which allow children to sit in the saddle from a tender age. Currently in Italy there are hundreds of pony clubs, present in almost all the regions, the island of Sardinia included.

Children not only learn to ride with the pony, but they establish a psychological relationship and are stimulated to love animals. Many Italian riders who represent Italy in the international competitions, learnt to ride first on ponies when they were

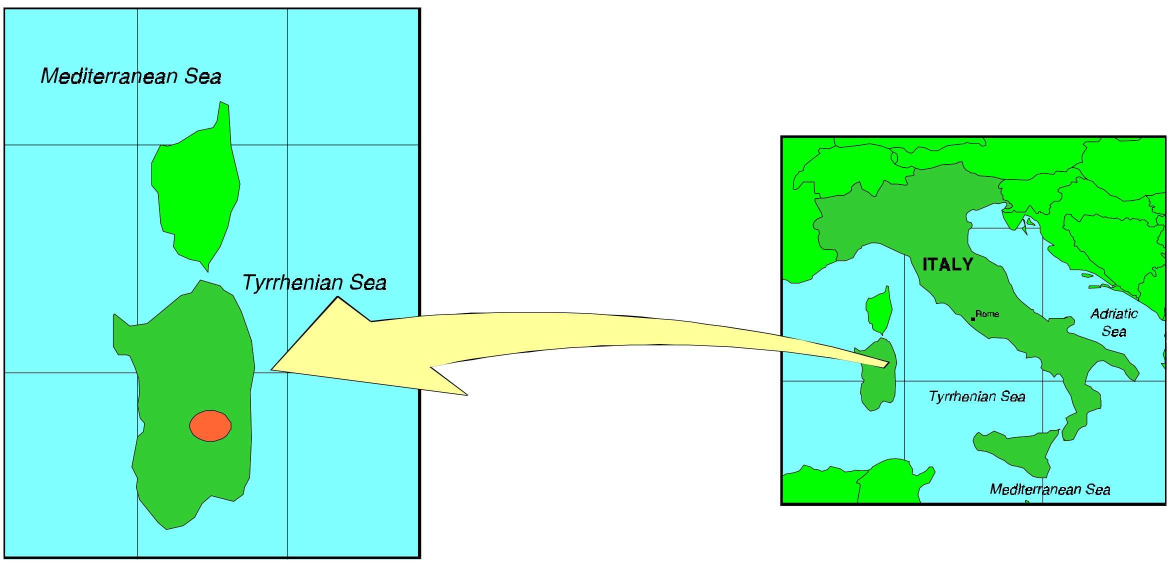


Figure 1. Geographic position of Sardinia and Giara higland (in circle) in respect to Italy.

children. The demand for ponies from individuals is constantly increasing. Ponies are generally imported to Italy from England, Ireland and France, at an average price of 3-4 millions liras (about 2 000-3 000 dollars) per head. The training with the ponies for children starts like playing with a new friend. The group games develop sociality, according to the witticism “one for all and all for one”. An example of these group games is the sack race (one partner riding and the other bouncing in the sack and holding the pony by the reins) or the slalom competition between cans or stakes, etc. The children not only learn to enjoy themselves but, above all, to respect the animals; a school of sport is a school of behaviour, where self-control and steadiness of mind are emphasised.

The children’s love for the ponies is something, I would say, innate, which has existed for a long time. A relationship of comprehension and friendship is established between the child and the foal. The pony for its particular efficiency of the nervous system (10-12 times more rapid than that of man) can face an obstacle, an impediment, with greater safety and awareness than that of its rider; and the child adapts to such a condition and becomes more confident. Horseback riding is one of the most formative schools and most socialising activity for children. In the Sardinian population, love for horses has existed for a long time; from this ancient love stems the great importance of saving the future of the Ponies of the Giara, source of wealth and testimony of the Sardinian tradition. In the figurative sense, facing the obstacle also means facing the problems of life and trying to resolve them. In a lot of human situations, incapability to take an immediate decision when faced with a problem, involves serious psychic consequences and forms of depression.

Figure 2. Giara horses in their natural environment.

Figure 3. Chestnut mare (From Studfarm of Dr. A. Tatti).

In many pony clubs the psychology of the horse is also considered in the teaching programmes. For example, in Turin the Pony Club sends its founders to the primary and secondary schools to give lessons in the classroom with films and slides, etc. and to offer free invitations to visit to the club and to attend the first classes.

There are currently different breeds of pony in the world; in Europe the most well known are:

- Pony-Great Britain (Country of Wales) 1.22-1.27 cm height;
- Dartmoor Pony, (County of Devon), they also reach the height of 1.40 cm because they have been crossed with English pure-breds;
- Irish pony (County of Galway) of Irish origin not modified over the centuries (1.32-1.42 m height); and
- Shetland Pony (Shetland Islands, off coast of Scotland); 0.80-100 cm average height.

The latter, isolated in the numerous islands of the archipelago, had to adapt to the environment characterised mainly by cold seasons and shortage of forage. For this reason they have been selected for their small form, more compactness, rusticity and thick hair to withstand the cold. They are also at risk of disappearing because of man's use of them under difficult conditions in the mines as pit ponies.

The ponies of the Shetland Islands were famous, instead, for their high economic interest and they are requested for their small stature and notable spirit of adaptation and docility.

There are still different families of pony: Norwegians; Corsican deriving from the mountainous regions of Corsica where they still live in the wild and are used for saddling and for small jobs (height 1.30-1.40 m); Pony of the Moors (France) of Arabic origin, which became small because of the poor soil (height

1.35 m maximum). Besides, there are also the Icelandic pony similar to the Shetland, and the ponies from Spain and Portugal. The Giara ponies, of which few characteristics are known abroad, can be classified among the latter type of ponies. Their origin was lost a long time ago, however good testimonies regarding the existence of the ponies in Sardinia can be approximately dated to the VII century B. C.

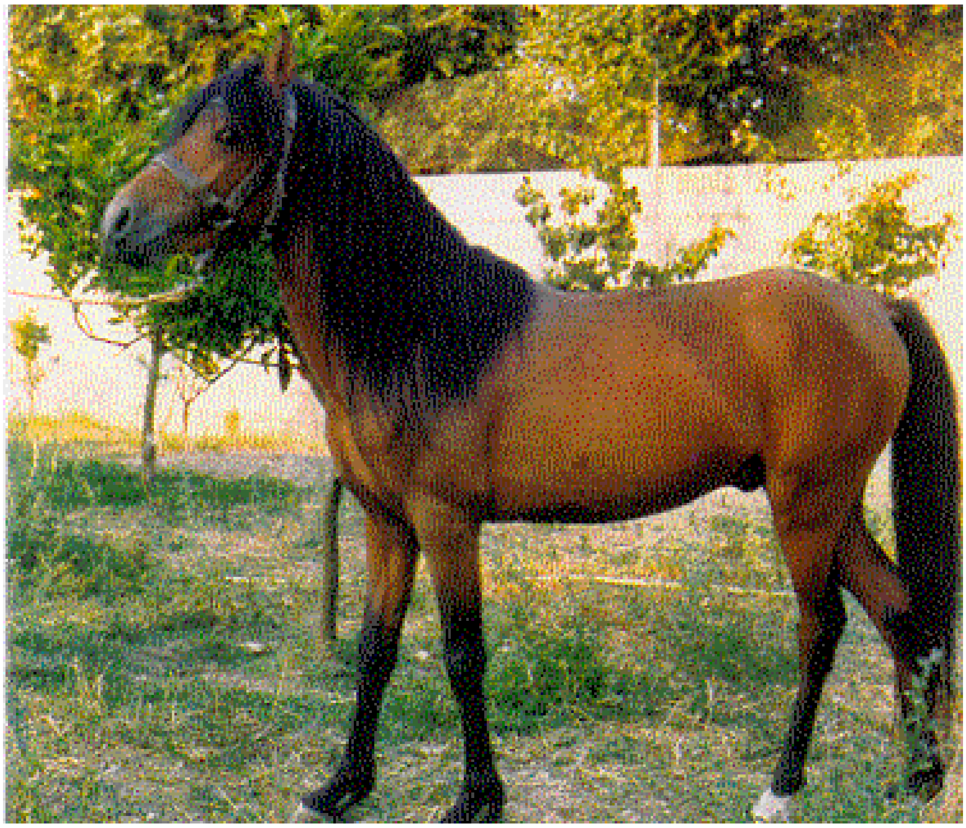
Recently, research on the haemoglobin polymorphism , (Manca L.), has shown some analogies (frequency of rare haplo-types) with the Arabic horses from North-Africa.

Besides, research carried out in Sardinia to ascertain the presence of specific antibodies in blood serum for various disease has shown similar conditions to the other horses of Sardinia. Their absolute negativity for the flu disease was remarkable.

There are no differences in the number of the chromosome (64) compared with other horses; therefore they are not wild horses but must be considered as horses which have returned to their wild state.

It is clear that these equines were at first used by the local populations for country work, mainly the threshing of wheat by treading. Subsequently, when their use lost economic interest, the Giara ponies, sheltered in the Giara highland, underwent a natural selection through which they have been selected for rusticity, smaller body and higher resistance. This was also verified in Corsica and, moreover in the famous Shetland Islands, where the smallest animals can be found.

The conformation of the Giara pony is different from that of the Shetland Islands. The latter breed has a brachyimorphic-type constitution, that resembles a miniature heavy draught horse; while the Giara ponies have kept their dolychomorphic appearance. It is estimated that at present in the highlands of the Giara there are approximately 600 head, naturally divided in herds. Figures 3, 4 and 5 show a chestnut mare, a



F*igure 4. Bay stallion (From Studfarm of Dr. A. Tatti).*

bay stallion and a mare with suckling colt, respectively.

Some of the most interesting characteristics that the foals exhibit according to natural variability, are the following:

- Constitution: meso-dolyichomorphic;
- Hair coat: bay, black, chestnut, clear mantles;
- Height at withers: 128-132cm;
- Live weight: 170-220 kg;
- Head: adorned by abundant forelock, often long;
- Neck: strong, wide at chest, thick mane;
- Trunk: long with light back-lumbar depression;
- Legs: prolonged with good muscular structure, equipped with long and resistant shin; small hoofs, resistant to rough ground;
- Other characteristics: vivacity, safety and agility; notable frugality; curiosity towards people and good attitude to domestication.

Finally, it is necessary to add that it would be a serious error to cross these equines with other breeds to increase their stature. In the past such crosses have been made to increase meat production. If conservation efforts succeed in preserving the breed at its present stature, the Giara pony could result in a notable economic resource for Sardinia.

Psychology

The relationship between horse and man has intrigued thinkers since ancient times. Cicero, Plinio; and more recently Buffon, Lamark, Darwin, etc. must be remembered.

In France, one important Museum of the Horse in Saumur was created (in the area near Nantes-Orleans) that, among other purposes, has the aim of stimulating the curiosity of the visitors and the interest of the researchers in the knowledge of the animal psyche and the principal affective stages.

Main Affective Stages

- *Language:* expressed by attitudes, and sometimes accompanied by neighs of particular intensity, recognisable by the keeper; from the physiognomy with facial

Figure 5. Mare with suckling colt

Figure 6. Children at their first experience with Giara pony.

mimicry; from the gait of the head, from the movement of the ears and the lips, etc.

- *Fear:* sense of uncertainty and restlessness , that can degenerate, in situations of imminent danger, into reactions of dismay (almost madness) or of escape or of paralysis, provoked from the supreme instinct of survival; in such cases they produce physiological effects similar to that of man: cardiac acceleration, cooling of the body; tremor; erection of the hair and release of the sphincters.
- *Joy and sadness:* release and escape of the young foals when they go into the open air and into the fields; the mother's recognition after a long absence; contrarily, in case of sadness, low head, abandonment, weariness.
- *Anger:* occurs especially in stallions, during the mating period, when they become impatient and can bite and kick.
- *Revenge:* vengeful instinct toward those who maltreat them. Their memory is indelible.

Genetic Aspects

It is important to underline that losing a breed means the disappearance of a genetic patrimony of an incalculable value which cannot be rebuilt. If we consider that the genes can be thought universal, (they can be transferred from a nucleus of a cell to another one of the living world, without distinction among plants, animals and, in theory, human kind) their peculiar relevance is also evident in the future, with the advances of genetic engineering.

Actually we do not know the chromosomal map of the ponies of the Giara and very little is known about their specific genes. The knowledge on the action of such genes could help in understanding some illnesses and hereditary imperfections , particularly on the defence of the cellular membranes, and on the impediment of the formation of free radicals.

Conclusions

In these last years the initiatives to save the foals of the Giara have assumed an increasing incisiveness. In 1976 the Breeders Association of the Sardinian Pony of the Giara was constituted with legal centre in Genoni. In 1991 the Institute for the Horse Improvement received in concession from the Monte Pascoli Regionali (Regional Mountain Pasture) the farm "Lavra" comprehensive of approximately 684 hectares in the highland. The farm has been fenced and numerous ponies have already been acquired in conformity with the requisite of the breed.

Besides, the decree of 27/07/90 promulgated by the Minister of Agriculture established the Register of the Equine Populations, referable to local ethnic groups. The Italian Breeders Association established the formalities of the register of breed (foals and fillies, breeding mare registry; stallion registry) and substituted the old tagging system by the insertion of a microchip in the left side of the neck. The University of Sassari, with the invaluable help of the Faculty of Veterinary Medicine, introduced an essential contribution for health, survival and better knowledge of the ponies of the Giara.

Currently, the mayors of 12 villages involved in this topic, the presidents of three Mountain Communities and the three Chairmen to the environment of Nuoro, Oristano and Cagliari have established an agreement to create the Park of the Giara.

The initiatives, summarisedabove, show that the public, the technical community and the politicians have become aware of and involved in the issue of the safeguard of the ponies of the Giara. However, to help sustain the breed on economic basis, it is important to make people aware of the role of the breed and to set up a medical-sporting centre for children.

The fundamental objectives of the Centre can be summarised in the following way:

- To allow the children, in the most suitable seasons, a period of rest and sport during which they can learn to love the foals and to learn the equestrian sport (Figure 6);
- To allow disabled children (autistic etc.)[1] to frequent the suitable medical centre for their health and to recover, close to the foals, courage, interest in life, and mitigate their illness by improving the clinical picture with a notable recovery toward normality.

Close to these two fundamental parameters (the care and the health of the child) important tourist returns are appearing. This offers the possibility, not only of lodging in the different villages those tourists who come in search of uncontaminated environments and horseback riding, but also to provide horse-riding and trekking and acquaint them with the beauty and the nature of the Giara.

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[1] Autistic is the psychic attitude by which the subject lives closed in on itself, detached from the sense of reality. Subjects have a tendency to isolation and to close in on himself in an internal dream-life. Autism can be a prelude to psychic illnesses.

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