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GOAT BREEDING IN LOW INPUT PRODUCTION SYSTEMS: INTERGRATING VALUES AND MODERN BREEDING TECHNOLOGIES FOR IMPROVING INSTRINSIC ROBUSTNESS

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Abstract

Low input production systems operate on long term values of supporting stable livestock production through efficient and sustainable combination of various production resources to achieve the desired production objectives. Strategies of goat breeding in low-input systems that emphasize on more robustness are a challenge now more than ever, owing to global environmental changes. These changes have exacerbated environmental heterogeneity, low feed availability and varied stresses that these systems are exposed to due to drastic variation in weather conditions, epidemic pressures, and feed availability, among others. Therefore to improve robustness, breeding should aim at increasing versatility of the goats to the changing environments. Characteristics of goats that enhance robustness are influenced by a range of biological mechanisms which are not exhaustively explored to be able to optimise breeding programs for low- input systems. The targeted quantitative traits are complex and influenced by many genes as well as the environment. Performance in low-input goat production systems is influenced by largely varying environmental conditions. Therefore, G x E interaction is envisaged. Most modern breeding technologies that can be used to improve intrinsic robustness have received little utility in low input production systems. For instance genomic selection, a high through put tool for genetic improvement of complex traits and reproductive technologies that facilitate rapid dissemination of superior genetics have achieved low utility in these systems. While these technologies may not have out rightly been outlawed, values espoused in low input production systems limit their use. It is therefore important that the concept of system values is discussed in view of incorporating modern technologies of animal breeding in these systems.

Keywords: system's values; intrinsic robustness; modern breeding technologies; low input goat production systems

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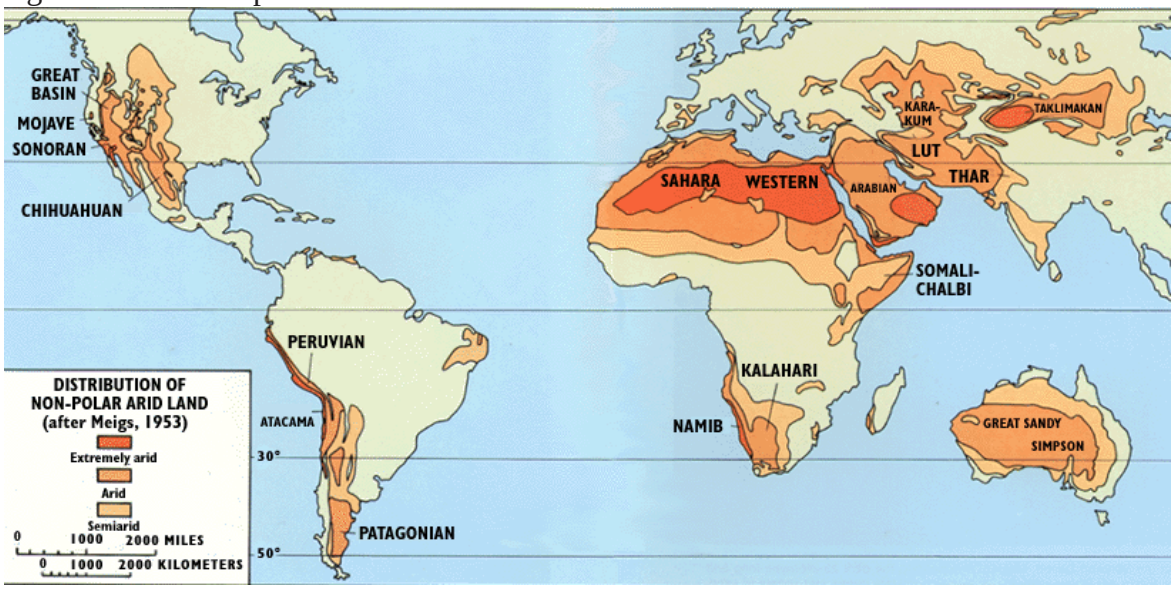
1. Introduction

A low input production system is a production environment where one or more rate-limiting inputs impose continuous or variable severe pressure on the livestock, resulting in low survival, reproductive rate or output. Output and production risks are exposed to major influences which are beyond human management capacity (Galal et al. 2000). The largest proportion of the world's goat population is raised under such systems which are found mainly in marginal rangelands and/or by poor rural households (Table 1 and figure 1). Producers raise goats under this system primarily by default rather than by choice owing to their limiting production resource base and the prevailing climatic conditions. Due to these limiting conditions of production, the survival ability and productivity of the goat largely depends on its efficiency in utilising the scarce production resources and adaptability to the stress conditions. It therefore implies that goat breeding for low input systems should aim at enhancing robustness of these animals to enable them remain resilient.

Figure 1: World map of arid and semi arid lands



Source http://pubs.usgs.gov/gip/deserts/what/world.html

Goats are considered to be Resilient when they are able to subdue strenuous conditions (perturbations) to survive and remain productive (Tompkins and Adger, 2004). When the resilience of the goat traverses production environments, then it is said to be robust. Intrinsic robustness refers to the animal's ability to invoke their natural biological and physiological processes to remain functionally productive under a variety of production conditions (Napel et al., 2006). For instance, a goat is said to be robust when it produces during favourable conditions and be able to sustain production under strenuous circumstances. Strategies of goat breeding in low-input systems that emphasize on more robustness are a challenge now more than ever. This is because of the global environmental changes that have exacerbated conditions of environments heterogeneity, low feed availability and myriad stresses to the animals. These conditions can be managed to sustain production through efficient management systems as well as selective breeding for traits that enhance robustness. Adoption of efficient management systems are well beyond the economic ability of many goat producers and contravene some values of the production system. This leaves only selective breeding as the option to attain robustness in goat

populations. It is however not within the realm of the systems values that all selective breeding approaches may be acceptable in the low input goat production systems.

Table 1. Trends of goat populations in the major goat producing regions

	Year of Production			
Region	2002	2004	2007	2010
Southern Africa	11384713	10856405	11307088	11630034
Eastern Africa	71226155	80394573	88712185	92037199
Northern Africa	56458940	58561730	60543020	61297640
South America	20628142	21640297	21292179	21255665
South-Eastern Asia	21599433	22691830	23902317	26391709
East and southern Europe	16238796	16569294	15689655	14229364

Source: FAOSTAT, 2012

Traits that influence efficiency and hence robustness are polygenic with complex mode of inheritance. Improvement of these traits requires high through put genetic technologies for meaningful genetic progress to be attained due to their low heritability estimates (Bett et al., 2012; Lopes et al., 2012). Conversely, low input goat systems implicitly espouse values that hamper utilisations of these technologies. This paper therefore seeks to discuss the concept of goat breeding for improved intrinsic robustness from the stand point of the values of the production systems.

2. Robustness and adaptation

Ostensibly, low input production systems espoused values that lean on adaptation rather than control. Systems that enhance adaptation focus on stabilization of animal production and income using the strategies such as enhanced dynamic balance, indirect management, and self regulation among others. This is contrary to control which emphasizes protection of animals from unwanted fluctuations that influence production as much as possible (Napel et al., 2006). Robustness could therefore be considered as adaptation across a variety of environments. Prior to adaptation there is exposure of the animals to the environment, the response of the animal leading to the animal conforming to the environment constitutes adaptation. These two components (exposure and conformance) similarly apply to robustness which involves serial exposure of the animal to a variety of environments eliciting conformance. For this to happen, robustness thus adopts a rolling ball on the plane model (Figure 2) in which the ball rolls to where the force is least in order to conform to the prevailing circumstances.

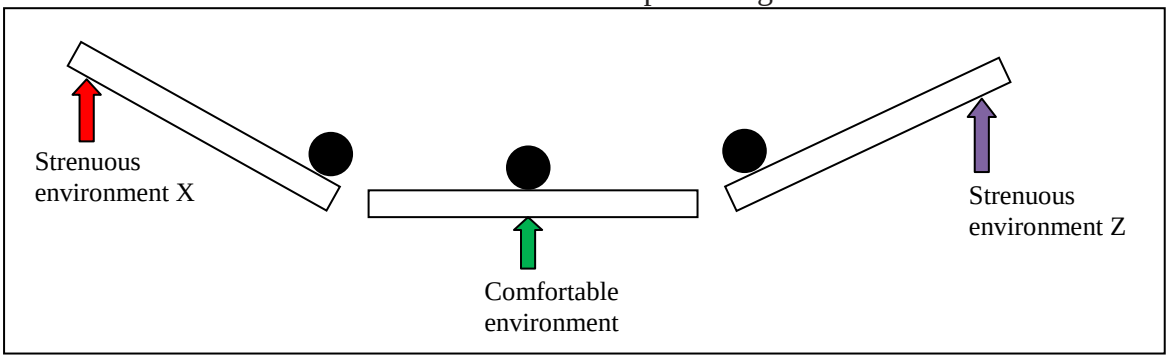


Figure 2. The rolling ball model that explains robustness in animals under low input systems

3. Values of low input goat production system - system's efficiency

Low input production systems operate under presupposed values as presented in Figure 3. These values determine objectives of production and hence the levels of inputs and outputs. The values are upheld by the producers due to the environmental conditions in the major production areas (Table 1 and Figure 1).

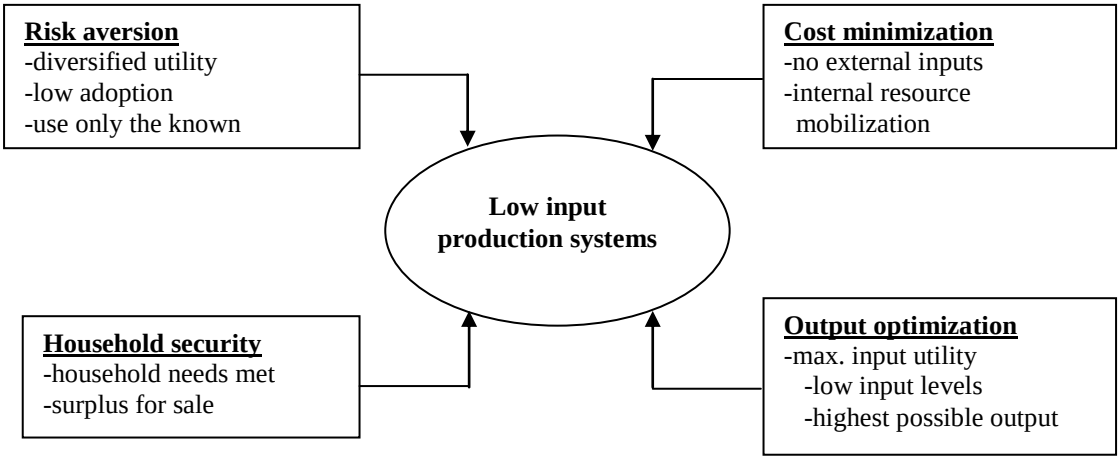


Figure 3. Schematic presentation of the values espoused by the low input production systems

3.1.Cost minimisation

Low input systems of goat production operate on strategies that minimise cost of production. This is achieved through minimal use of external inputs, efficient utilisation of on farm resources, recycling and improvisation. It is not uncommon to find prefabricated housing for goats in these systems (Bett, 2009). The extent to which goats are housed is relative as well as the degree of improvisation and depends on climatic conditions and risk of predation. In arid and semi arid areas, goats are kraaled together with sheep using thorny bushes to wade of wild animal predators. In cold areas goat housing aims at securing animals against cold (Bett, 2009). Animals feed on natural browse with minimum supplementation in form of mineral lick. There is flock fragmentation to enable preferential feed supplementation. Curative treatment of sick animals is preferred to prophylactic approaches of disease management. In extensive systems, ethno veterinary and use of indigenous knowledge of animal health care thrive as a cost minimisation strategy. In order to minimise costs of breeding services, producers tend to raise their own replacement stock and keep the rate of replacement as low as possible. Bucks are either raised internally or sourced from the neighbourhood. Due to afore mentioned strategies of feeding, housing and animal health management, selection decisions are geared towards goats that can adapt to the conditions in order to keep the costs of rearing as low as possible. This could partly explain the low rate of genetic gain observed in these flocks.

3.2.Risk aversion and household security

Studies have shown that goats under low input systems are kept to meet various aims (Bett, 2009; Kosgey et al., 2008). One of these aims is to ensure household food and social security (Kosgey et al., 2008). Consequently, producers endeavour to minimise production risks as much as possible in order to sustain the food and social security of the household. Used of adapted animals as well as refraining from breeding technologies that have not been tested in the system is part of the risk minimisation strategies. The role of goats as insurance of households

against risk was ranked as high as cash income in a study of small ruminant production systems (Kosgey et al, 2008). In another study to assess the influence of incorporating risk, disease resistance and producer's preferences in definition of breeding objectives for dairy goats in the smallholder systems in Kenya, producers preferred goats with minimal disease risk (high disease resistance) (Bett 2009). The tendency of goat producers avoiding risk is attributed to their poor disposition to resources in the event the anticipated risk factors become real. This analogy explains why most of the goats kept in low input systems are indigenous to the production environments.

3.3.Output optimisation

Low input systems emphasis efficient resource use. Producers aim at optimising production i.e. using the least possible inputs to achieve the highest possible output; rather than maximising production (use possible level of inputs to attain the highest possible output). In optimisation, inputs are used at their best level of production. Given the resource constraint in these systems, producers have to maximise the utility of the inputs available. As a result, the survival of the goats is highly dependent on their efficiency to use the available resources and ability to adapt to the conditions they are subjected to.

4. Breeding for intrinsic robustness

4.1.Traits that influence robustness

Intrinsic robustness refers to the ability of the goat to remain resilient and productive under varied conditions. This implies that goats under low input systems are produced under very heterogeneous environments. The viability of the goat under these environments depends on its efficiency in invoking the necessary biological functions that would facilitate its survival and performance. Breeding for intrinsic robustness would therefore require improvement of the goat's functional efficiency by selecting for traits such as residual feed intake or conversion efficiency, periodical survival (e.g. pre and post weaning survival), disease tolerance/resistance, heat tolerance (for those raised in hot and dry areas) high conception, kidding and weaning rates (Omondi et al., 2008). These traits ensure efficient resource utilisation, versatility (long flock-life) and availability of replacement stock. Other than functional efficiency, there is need to also improve production performance. Therefore trait such as periodical growth performance (e.g. pre and post weaning growth), average daily gain, milk yield and milk composition (e.g. butter fat and protein content) are important because they directly influence the revenue streams into the production system (Bett et al., 2007; Omondi et al., 2008).

The expression of functional and productive traits that directly determine the robustness of the goat is a function of complex biological processes. These processes are under the influence of a plethora of genes at different loci and exhibit the infinitesimal model of inheritance. Besides, the traits are also influenced by environment. Given the large influence of varying environmental conditions (both temporal and spatial) on performance, interaction between genes and the environment is highly envisaged. In this case, environmental conditions and genes found to influence a given trait in one environment will not always be the ones found in another. This is explained in the variability observed in variance component and heritability estimates reported in literature (Abbasi et al., 2012; Aboul-Naga et al., 2012; Ahuya et al., 2009). It is therefore important that selection methods adopted to advance genetic improvement of intrinsic robustness in goat populations should take a multiple trait approach.

4.2.Selection methods for intrinsic robustness

Traditionally, selection methods to improve functional traits that influence robustness hinge on the principle of correlated response to selection. Animals are selected for improved productive performance within their production environment so that the functional traits such as adaptability to the environment are improved indirectly. Though improvement has been achieved as demonstrated by the estimates of genetic gain from breeding programme evaluation studies, these method of selection is marred with challenges arising from low heritability estimates of the traits, high environmental influence on the traits and the high mobility of genetic material outside the point of selection (Ahuya et al., 2005). Consequently, the rate of gain would be increased if direct selection of goats for the traits that enhance robustness is adopted.

So much focus is on the low estimates of heritability of functional traits during design of breeding programmes that hardly is attention paid on the underlying additive genetic variance in these traits. This skewed focus has resulted in a popular but wrong deduction among animal breeders that functional traits cannot be effectively improved by selective breeding. Heritability is the additive variance expressed as a proportion of phenotypic variance. Therefore the estimate of heritability will be dependent on the phenotypic variance which is also subject to environmental variance. Since these traits are greatly influenced by the environment, they tend to have large environmental variance resulting in inflated phenotypic variance that overshadows the additive genetic variance though significant. The resultant is low estimates of heritability. Therefore, though estimates of heritability for functional characteristics are low, the underlying genetic variation in goat populations is large enough to enable reasonable response to selection (Lopes et al., 2012). Therefore direct selection based on phenotypic records of performance could be utilised to effect genetic progress. However, where the underlying variation is small, alternative molecular selection approaches such as marker assisted selection and genomic selection could be used. This is because these selection approaches are at the gene level hence more accurate resulting in higher genetic gain in both functional and productive traits than the conventional selection based on phenotypic records. Despite the known advantages of MAS and genomic selection, they have found limited utility in the low input goat systems. This could be attributed to some of the values of the low input goat systems.

5. Integrating system's values with modern breeding technologies

5.1.The basis of the system's values

In order to effectively integrate modern breeding technologies in low input systems, it is important to understand the operational basis of the systems. Goats under low input production systems are raised by producers who have low levels of disposable income. A large number of them live on less than a dollar per day; consequently, their ability to spend is low. Therefore, the cost minimisation strategy prevalent in this system is not a strategy out of business decision making process, but rather occurs by default due to the poverty situation of the producers. The world's largest proportion of goats is produced in marginal environments. In Africa and Asia for instance, goats are mainly produced under arid and semi arid conditions (Kosgey et al., 2006). Given these conditions and the little resources the producers have to manipulate the production environment, only efficient goats survive. It is therefore not a coincident that animals found under this system are mostly indigenous to their environment. Due to their adaptability to the environment, they require minimal resources to be viable.

5.2.Encourage market orientation of the system

Goats play multiple roles in low input systems ranging from tangible economic roles to intangible roles such as social security and traditional rites (Kosgey, 2004). In the pastoral systems which form the bulk of the low input systems, wealth is regarded in terms of the size and quality of the flock. Goats are kept as income reserves to cushion households against undesirable eventualities. These form the primary objective of keeping goats and sale is normally the last option. A study on needs for research and development in livestock recording systems in transition and developing countries observed that production systems which had low market contact were diversified playing more intangible roles than economic roles when the market contact is low (Peters and Zumbach, 2002). This therefore implies that more specialisation into market oriented objectives would be achieved when there is high contact between the system and market. Consumer demands will consequently have a big impact on the systems and ultimately determine the integration of the breeding technologies into the system.

5.3.Engagement of policy makers and other players outside the system

It is apparent that producers within the low input systems have to cope with various production challenges. Like many vulnerable societies, adoption of modern technologies to alleviate the system's challenges will highly depend on the input from external sources than within the system. This can be achieved using various approaches:

a) Formulation of development policies that target production environments where these systems are prevalent

Most of the low input goat systems are found in marginal areas. In the tropics and sub tropics, these systems are found mainly in arid areas that suffer high ambient temperatures and low rainfall. These conditions subject the goats to heat and nutritional stresses. In addition, these areas suffer inadequate infrastructural development and overhead facilities. Formulation of policies that would facilitate establishment of irrigated feed resource production would alleviate the nutritional stress that causes low production and death of stock during dry seasons. Development of transport and communication infrastructure, and overhead facilities will open up the production areas and improve accessibility. This will result in reduction in costs of some of the production resources.

b) Engagement of processors and marketers of goats and goat products

The low disposable income situation of most goat producers under low input systems, limit them in acquisition of primary production resources. One way of improving production under these circumstances is to shift the cost of production to other players in the value chain. This can be achieved through engagement of processors in a contract arrangement to supply inputs that support production. In such a case, the processors/ marketers of goat and goat products would buy the inputs and supply them to the contracted producers *apriori* such that producers pay for the inputs through a check off system during delivery of goats and goat products. Such a programme has been effective in improving the quality of breeding stock and milk production in smallholder dairy cattle systems in Kenya (EADD, 2011). The success of such programmes however, depends on how the producers are organised. It is therefore important that such programmes do not upset the social fabric of the communities of the producers. For instance, interventions towards pastoral goat systems in Kenya should aim at upholding the communal approach to production issues given their communal lifestyle. This is also emphasised elsewhere in a review of technical and infrastructural issues in low input small ruminant genetic improvement programmes (Kahi et al., 2005; Kosgey and Okeyo, 2007).

c) Offer modern breeding technology services as a public good

Breeding services is a cost component of the production system. Therefore producers in low input systems would hardly embrace technologies that demand high input outlay. Most governments on the other hand have livestock research centres. These centres could be used as nucleus hubs for improvement of goat genetics in collaboration with the low input producer groups. In this collaboration, the producers would provide the base population for selection of animals and effectively participate in formulation of breeding objectives for within breed improvement. The research centres, since they derive their funding from the ex-chequer, would apply the high through put genetic improvement technologies such as MAS and genomic selection to effect genetic change in the populations with regard to agreed upon objective traits. Other than government research centres, non-governmental organisations and international research laboratories could also bear the costs of these technologies (Dubeuf, 2005). The improved genetics would then be disseminated using government supported artificial insemination, buck rotation and doe pass on schemes. Some of these dissemination schemes have successfully been used in improvement of dairy goats in smallholder systems (Ahuya et al., 2005).

6. Conclusion

Unlike other production systems where producers make deliberate decisions to pursue profitability, producers in low input systems find themselves in this system by default either as a result of low household disposable income levels or being within production environments considered marginal (e.g. arid and semi arid). Their production circumstances are therefore not as a result of irrational business decisions but rather rational decisions for sustainable productivity. To enhance robustness of goats using modern breeding technologies, interventions from outside the systems by engaging stakeholders in the value chain but outside the production bracket would be important so that costs of production are shifted either directly or indirectly.

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