Effective strategies for local breed definition and conservation

Estrategias efectivas para la definición y conservación de razas locales

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ABSTRACT

Conservation of local breeds (landraces) is difficult but important because they are likely to have traits of adaptation as well as of production. For their final composition, breeds depend on a combination of founding genes, isolation, and selection, and each of these must be evaluated carefully when considering a landrace. The usual steps in animal conservation are discovery, definition, securing and sustenance. iscovery is helped by using local knowledge of animal resources, as well as by outside expertise in breed and animal resources in the region. Definition is deciding which animals to include, and which to exclude, in a conservation program. This can be accomplished by developing a phenotypic matrix that is scored for aspects typical for purebreds and crossbreds in the local area. Securing the resource can sometimes involve outright rescue and removal of very small and very endangered populations. More frequently, it may involve organizing breeders and breeding of the animals in order to assure a broad genetic base to avoid inbreeding. Secure breed resources also depend on high demand for breed-specific products.
Key words: local breed, landrace, rare breed, breed conservation

RESUMEN

La conservación de razas locales (*landraces*) es difícil pero importante, porque es probable que posean características de adaptación y también de producción. Las razas dependen para su conformación final de una combinación de genes fundacionales, aislamiento, y selección, y cada una de estas debe ser evaluada cuidadosamente cuando se están considerando a las razas locales. Los pasos más comunes para la conservación animal son: descubrimiento, definición, preservación y mantenimiento. El descubrimiento se ayuda con la utilización del conocimiento local sobre los recursos animales, como también por la experticia externa en razas y recursos animales dentro de la región. La definición significa decidir cuáles animales incluir dentro del programa de conservación, y cuáles desechar. Esto se puede lograr desarrollando una matriz fenotípica que se califica con los aspectos típicos de los animales puros y los cruzados dentro de la localidad. La preservación del recurso algunas veces puede involucrar el rescate propiamente dicho y la remoción de una población animal muy pequeña y muy amenazada. Más a menudo significa organizar a los criadores y establecer la reproducción de los animales para asegurar una amplia base genética que impida la consanguinidad. La preservación de los recursos genéticos animales también depende de que exista una alta demanda por los productos específicos de la raza.
Palabras clave: raza local, *landrace*, razas inusuales, conservación racial

INTRODUCTION

Standardized, trans-national breeds are increasingly what comes to mind when the word "breed" is used by most people involved in animal production. Such breeds have a high level of definition and documentation, and are rapidly becoming the most common breeds used for agricultural production throughout the world. This has long been true of temperate regions, and is also increasingly true in any region with ample feed and other support such as health inputs.

In contrast, local breeds (the English word "landrace" describes these) are usually associated with more peripheral or disadvantaged production systems. Landraces usually have low levels of documentation, and also little definition that can aid in their effective conservation. These issues are important because landraces generally have high levels of environmental adaptation and most of them remain productive in the face of limited inputs. Their effective conservation is therefore highly important as security for future agricultural systems, especially in systems with few available inputs. The relatively low level of documentation of the production levels of landrace animals makes their conservation situation especially risky, because they are often replaced by trans-national breeds before the true potential of the landrace is fully known. Once they are gone they cannot be replaced.

One problem in landrace conservation is an understanding of the definition of "breed." The term "breed" has various cultural contexts, to the extent that FAO generally declines to give a firm definition of "breed." A reasonably restrictive definition is that a breed is a group of animals that is phenotypically similar, recognizable from other members of the same species, and when members of the breed are mated together the result is the same phenotype. Another way to put this is: *"A group of animals that*

has been selected by man to possess a uniform appearance that is inheritable and distinguishes is from other groups of animals within the same species" (Clutton-Brock, 1981). This definition is powerful, because at its core is the concept that a breed is a reasonably uniform genetic resource. It is this genetic uniformity that provides for the predictability of outcomes, and predictability is at the core of the utility of breeds. Each breed should represent a genotype that produces a predictable phenotype so that producers can select whichever breed is likely to succeed in their environment and for their production goals.

Breeds, as genetic resources, usually depend on a combination of foundation, isolation, and selection to achieve their current status. These act together in important ways, and each must be present for an effective breed to result (Sponenberg, Beranger and Martin, 2014).

Foundation is often the result of accidents of history rather than deliberate choices made concerning which specific animals would be introduced into which regions. In the Americas this foundation was often Iberian, and Iberian livestock in their own turn have a globally unique foundation due to the peculiarities of livestock introduction into the Iberian Peninsula both from Europe and Africa. This unique foundation makes criollo landraces of special interest and importance globally, despite the fact that their foundation was largely accidental due to their convenience at ports of embarkation from Iberia. A more significant experiment could hardly have been devised any better by deliberate consideration. These resources need to be very carefully conserved in order to not lose the opportunity they present for sustainable animal production.

Isolation, in a similar nearly accidental manner, usually was imposed by limitations to communication and transportation. These limitations were much more present in the past than they are currently, which has changed the fate of many landraces. Isolation in the past could be assumed, and did not need to be deliberate. In today's world of improved infrastructure for both communication and transportation it is more and more necessary for isolation to result from conscious choices and strategies. Practical ways to assure high levels of isolation in local landraces are becoming increasingly difficult.

Selection is also important in shaping genetic resources. Selection has two main aspects; one of these is natural selection imposed by the environment in which the animals reside. While health and nutritional inputs can minimize the importance of environmental adaptation, it remains true that all breeds are subjected to some level of natural selection. When natural selection is at a high level, adapted genetic resources are the result. A second type of selection is imposed by human owners. Human selection is subject to change as desired products and infrastructure change over time. The two types of selection, natural and human, can be very effectively used together to result in adapted, productive breeds.

If the final concern of animal breeding is a functional breed, then a few additions to the basic definition of "breed" are appropriate. A functional breed is a genetic resource —as defined above— that resides and produces in a specific environment that has both natural and agricultural aspects. These aspects include ranges of temperature, humidity, and vegetation, but also include production systems and production goals that are imposed by human caretakers. This brings in the idea that these genetic resources are partners with human caretakers, ideally in a system that assures the survival of both humans and animals. It is essential to consider the cultural environment in which these genetic resources reside and produce if their conservation is to proceed logically and effectively serve their human partners.

Steps to Landrace Conservation

Landrace conservation must start from the very beginning. While local owners may know and appreciate the resource, most landraces have no formal definition. The result is that that outside observers, experts, and development planners can easily overlook landraces and fail to recognize their importance and role in local production. It is common for landraces

to be overlooked as genetic resources with real production potential, and to be lost to extinction by replacement with trans-national breeds.

The usual steps in effective landrace conservation are discover, define, secure and sustain. Each of these steps has challenges, and failure in any one of them leads to failure in conservation. Each step must be considered carefully in order to achieve success (Sponenberg et al., 2014).

Discover

Discovery of landraces is an essential first step in conserving them. Local breeds usually have a long track record of local recognition, but this does not always extend beyond the local area. In most of today's world the landrace needs to be more broadly accepted as an identifiable breed beyond the local area in order to survive.

In some cases, local breeders might not even recognize that they have something unique. In the islands of the west of Norway, the small local sheep (Villsau) were long kept by local breeders for their unique wool (Buer, 2014). However, not even the breeders fully recognized them as "sheep," and so they tended to only count their bigger commercial sheep for official census work. This put the breed at very great peril of slipping to extinction because not even the breeders fully recognized the resource. After establishing a more defined status for the breed the numbers went from a low of 500 in the 1970s to several thousand now, leading to a much more secure status for the breed.

Discovery can often involve interested outside experts or other enthusiasts that recognize a consistent genetic resource and alert not only local breeders but also the broader community. These outsiders can work together with the local breeders to secure the breed's identity, although local breeders and local knowledge remain a key component of successful programs (Perezgrovas, 2009).

Certain situations are more likely to contain landraces, and special attention can be directed at those. Landraces are more common in isolated areas, including those with rough geography. A second sort of isolation is the cultural isolation typical of some minority communities. Both natural and cultural isolation facilitate the persistence of landraces, and such locations should be diligently explored for unique genetic resources.

Define

Defining a landrace can be difficult, especially if the landrace has experienced any level of crossbreeding with outside animals. In today's world, most landraces have indeed been crossbred to some extent. Definitions of landraces can vary from "any animal from this location" to "animals from this location with these specific characteristics." The first sort of definition can be too broad, and can include crossbred animals that defeat the goal of relative genetic uniformity within a landrace. An extreme form of the second sort of definition can be so restrictive as to exclude many purebred animals. While individual situations vary, the most extremely inclusive and the most extremely exclusive approaches usually serve conservation poorly.

It is important to remember that landraces tend to be more variable than standardized breeds. Any effort to tightly standardize them runs the risk of eliminating much of the genetic diversity that is essential to their identity and function. As a consequence the definition for a landrace needs to focus on the essential components of breed identity, while being relaxed enough to allow for variation. Landraces especially tend to vary in color, as well as in the presence, absence, or number of horns. These characteristics are controlled by relatively few genes, and tend to be among the characteristics most quickly made uniform as breeds become standardized. The result is that many agricultural experts assume that a population that varies for color or horns is not a true breed in the genetic sense, when in fact it may well qualify as a breed if the underlying conformational and production phenotype is carefully considered.

One useful approach in evaluating animals for inclusion in landrace conservation is the development of a matrix of characteristics that can be used to eliminate animals with obvious introgression from other breeds. In most

cases the local history of the landrace and the potential sources of introgression are relatively well known, and the matrix can work to identify these accurately and efficiently. A few examples of the development and function of matrices can serve to illustrate their utility.

Horses of Colonial Spanish phenotype (also known as New World Iberian) still persist in the United States, but usually in isolated feral herds. From time to time new candidate herds come to the attention of the conservation community, and these herds need to be evaluated. Chuck Reed of the Bureau of Land Management in Rawlins, Wyoming, first came up with the idea of a matrix of characteristics against which horses could be evaluated for inclusion into the Colonial Spanish horse conservation programs. This matrix is presented as Table 1.

The essential concept is that the most typical manifestations of any selected characteristic are scored a "1," while the least typical are scored "5." The resulting score can be reduced to an average of characteristics that were scored, with scores near 1 being most typical and scores near 5 being least typical. This reduces biological complexity to a single score, which in most cases is not adequate to serve the practical function that is desired. It is important to emphasize anatomic regions that indicate breed type more strongly than other regions. In most cases these include the details of head and ear conformation, although this varies breed to breed and species to species.

The use of a phenotypic matrix focuses the observer on key breed-specific traits. Any one of those can indicate significant deviation from breed purity due to past crossbreeding. This makes the matrix somewhat complicated, because the wise result is more than a summation of scores, but rather a search for consistent deviations from the purebred type. Consistent deviation in certain key characteristics can indicate crossbreeding, despite other characteristics being acceptable.

For example the "El Rito" herd of horses were candidates for inclusion in the Colonial Spanish horse conservation efforts, and had several dedicated and active breeders. However, the horses' heads all had relatively plain nasal areas, although the remaining conformation was very Iberian. Evaluation of DNA revealed that a history of crossbreeding with Welsh Ponies was accurate, and that the herd was therefore not important to the conservation of the Colonial Spanish type. In contrast, the Lost Creek herd of feral horses in Wyoming was evaluated, scored well in the matrix, and was subsequently documented by DNA as typically Colonial Spanish (Cothran, personal communication, 2014).

It is important to reduce the matrix to include only breed-specific traits that indicate breed type. Characteristics related to conformational strength and general soundness are usually shared across breeds, and therefore contribute little to an understanding of the breed origins of an animal presented for evaluation. Important though these traits might be, they only confuse the issue of breed origin if they are included in this sort of matrix that is to be used as a tool to include or exclude animals from a conservation program.

In the case of Texas Longhorn cattle, the Iberian root of the breed has been endangered by introgression from both Indian zebu and northern European taurine cattle. These sources of introgression most usually change the character of the head, horns, tail, and croup, so a matrix dealing with Texas Longhorns can safely emphasize these body regions while ignoring most others. Experience by the Cattlemen's Texas Longhorn Registry in evaluating candidate cattle is encouraging, because fewer than 1% of cattle that pass visual inspection are subsequently revealed by DNA analysis to have introgression of other breeds (Davis, 2014). This is hardly surprising, because the external phenotype is closely related to the underlying genotype. This experience does indicate that a carefully constructed list of characteristics can indeed result in elimination of nearly all introgression from other breed sources.

The so called "Spanish Goats" in the USA present yet different challenges. In this case, the most unique phenotype is reasonably distinctive and cannot be confused with other common breed types in the USA at this time.

Table 1. Matrix of type scores for Colonial Spanish Horses

Most typical – score 1	Not typical - score 5
HEAD PROFILE	
Either 1. Concave/flat on forehead and then convex from top of nasal area to top of upper lip (subconvex) 2. Uniformly slightly convex from poll to muzzle 3. Straight	1. Dished as in Arabian 2. Markedly convex
HEAD FROM FRONT VIEW	
Wide between eyes (cranial portion) but tapering and "chiseled" in nasal/facial portion. This is a very important indicator, and width between eyes with sculpted taper to fine muzzle is very typical	Wide and fleshy throughout head from cranial portion to muzzle
NOSTRILS	
Small, thin, and crescent-shaped. Flare larger when excited or exerting	Large, round, and open at rest
EARS	
Small to medium length, with distinctive notch or inward point at tips	Long, straight, with no inward point at tip. Thick, wide, or boxy
EYES	
Vary from large to small (pig eyes). Usually fairly high on head	Large and bold, low on head
MUZZLE PROFILE	
Refined, usually with the top lip longer than the bottom lip	coarse and thick with lower lip loose, large, and projecting beyond upper lip
MUZZLE FRONT VIEW	
Fine taper down face to nostrils, slight outward flare, and then inward delicate curve to small, fine muzzle that is narrower than region between nostrils	Coarse and rounded, or heavy and somewhat square as the Quarter Horses, rather than having the tapering curves of the typical muzzle
NECK	
Wide from side, sometimes ewe-necked, attached low on chest	Thin, long, and set high on chest
HEIGHT	
Usually 13.2 to 14.2 hands high. Horses over 15 hands are not typical	Under 13 hands or over 15 hands is not typical
WITHERS	
Pronounced and obvious. "Sharp"	Low, thick, and meaty
BACK	
Short, strong	Long, weak, and plain
CROUP PROFILE	
Angled from top to tail. Usually a 30 degree slope, some are steeper	Flat or high
TAIL SET	
Low, tail follows the croup angle so that tail "falls off" the croup	High, tail up above the angle of the croup
SHOULDER	
Should be long, and 45 to 55 degrees	Short, and steeper than 55 degrees
CHEST SIDE VIEW	
Deep, usually accounting for half of height	Shallow, less than half of height
CHEST FRONT VIEW	
Narrow, and "pointed" in an "A" shape	Broad, with chest flat across
CHESTNUTS	
Small, frequently absent on rear, and flat rather than thick	Large, and thick
COLOR	
Any color. In populations the black-based colors are relatively common. No bonus points for any color, no suspicion of impurity on any color	No color is penalized

REAR LIMBS FROM REAR VIEW	
Straight along whole length, or inward to have close hocks and then straight to ground ("close hocks"), or slightly turned out from hocks to ground ("cow hocks") but not extreme. Legs very flexible. At trot the hind track often lands past the front track	Excessive "cow hocks." Heavy, bunchy gaskin muscle, tight tendons
FEATHERING ON LEGS	
Absent to light fetlock feathering, though some have long silky hair above ergot and a "comb" of curled hair up back of cannon. Some horses from mountain areas have more feathering than typical of others, and lose this after moving to other environments	Coarse, abundant feathering as is seen in some draft horse breeds
REAR	
Contour from top of croup to gaskin has a "break" in line at the point of the butt	Contour from top of croup to gaskin is full and round "apple butt" with no break at the point of the butt
HIP FROM REAR	
Spine higher than hip, resulting in "rafter" hip. Usually no crease from heavy muscling	Thickly muscled with a distinct crease down the rear
HIP FROM SIDE	
Long and sloping, well angled, and not heavy	Short, poorly angled
MUSCLING	
Long and tapered	Short and thick "bunchy"
FRONT CANNON BONES	
Cross-section is round. Best to palpate this below the splint bones	Cross section is flat across the rear of the bone

This matrix scores a variety of conformational traits related to Colonial Spanish Horse type. A score near 1 for each trait is most consistent with an Iberian origin; those with a score near 5 are much less typical.

When evaluating individual horses it is possible for a non-Iberian horse to be fairly low-scoring. This is much less likely when entire populations are scored, so that it is recommended that the matrix be used on populations rather than on individual horses. Populations that have over 80% low-scoring horses are likely to be Iberian in origin, and those with over 90% low scoring horses are nearly always proven to have had an Iberian origin. Those with 50% or fewer Iberian type horses are unlikely to prove out to be Iberian in origin.

On every horse, however many of these characteristics that can be observed should be scored. Add up the total score, and then divide that total by the number of items scored. A score of 1 is a very typical horse, a score of 2 an acceptable horse, a score of 3 a marginal horse. Scores of 4 and 5 deviate significantly from Spanish type, and any score this high needs to be carefully considered as indicating crossbreeding. In a population of purely Spanish origin the scores should cluster strongly in categories 1 and 2, with very few in 4 and none in 5.

These other breed types include Angora, Nubian, Boer and Swiss breed dairy goats. The most typical Spanish goat in the USA has long, twisted horns, medium sized ears that are carried horizontally but next to the face rather than straight to the side, and a straight or subconvex facial profile. Each of the other breed types changes that basic appearance, so the matrix needs to exclude those possibly crossbred types.

In the case of the Spanish Goat in the USA, it is very likely that some purely Iberian goats have phenotypes that could be confused with the crossbred types. Eliminating these types is detrimental to conservation success, but has few realistic alternatives in a species in which the low value of individual animals tends to preclude much DNA investigation. As a result, these confusing types have been eliminated from conservation efforts in the USA, even though some breeds in Spain and Portugal may well have these phenotypes (convex heads, shorter horns, larger pendulous ears). On the positive side, DNA from goats selected by emphasizing the more unique type has been compared to those of similar goats from South America, and has revealed strong genetic similarities, which further validates the use of a matrix in effective conservation. These results indicate that a phenotypic approach is indeed based on the underlying genome (Martínez, Landi, Gama, Delgado, Ribeiro, Cortés et al., 2012).

Deciding on a good definition for landraces, and then establishing a method for inclusion and exclusion of candidate animals, is important as the base for the conservation effort. Breed purity can be taken to a ridiculous extreme where high levels of uniformity will doom a population to inbreeding and decline. But, at the opposite extreme a highly crossbred population has unpredictable performance for production characteristics as well as for reproduction. At the crossbred variable extreme the underlying value of a breed is diminished. This is especially true of Iberian-derived criollo breeds, because their breed history and

genomes tend to be unique when compared to those of other European, African or Asian breeds. As a result they occupy a very privileged position for a role in rational food production based on the use of purebred regionally adapted genetic resources. As a result the definition and conservation of Iberian and Criollo resources are highly important.

Secure

After a definition is established, the next step in effective conservation is securing the population. This step can vary considerably depending on the resource, its location, and its relative level of safety. At one extreme an outright rescue might be necessary, where animals are removed from a precarious situation and moved to a safer location. This is often the case with feral genetic resources from islands, due to the negative effects such animals have on endangered native flora and fauna. Other situations can involve elderly breeders that leave behind valuable genetic resources upon their own death.

Rescues generally involve relatively few animals. As a result, population management becomes important to assure that a balance of the founders is represented in the rescued landrace. An extreme example is the Randall cattle breed of the USA, which rests upon a founding population of only 12 animals (Sponenberg, Creech & Miller, 2007). While it was impossible to completely avoid all inbreeding, close attention to mating within the population has resulted in a current breed population close to 500 animals. Such success is the goal of every rescue.

Most breed conservation situations are less drastic than a rescue. These involve developing procedures that assure enough purebreeding and purebred recruitment to guarantee survival of the breed. It has generally been the case in the USA that more formal breed definition and breeder organizations have served to enhance the security of most landraces. The breeders are generally proud of their livestock, and when others take notice their commitment to the breed only grows and deepens, which assures survival of the breed.

Landrace populations with relatively high numbers have less immediate need for drastic intervention than do the rescue situations with low population numbers. However, they still do need attention to population structure. It is relatively common for landrace populations to be divided into several distinct herds or flocks, each associated with a different family or owner. It is common for the more populous of these to be heavily used, even in the herds and flocks of the least populous. Through that process a few of the distinct bloodlines within the population can easily replace the genetic diversity that is contained in the least populous herds and flocks. Breeder education can help reverse that trend so that the rare pockets of diversity within the breed are kept strong and are encouraged to increase in number.

The population structure of many breeds requires a variable approach to maintaining the diversity within the breed. The most populous bloodlines can undergo selection for production, while the least populous will require more attention to conservation based on genetic representation of founders. Selection for production characters can then begin after numbers are increased and the breed population is more secure from loss.

Sustain

Sustaining viable breed populations generally has three components. One of these is sound biological management of the breed resource. The second is assuring a good market for the breed and its products. Third is a good association for breeders that facilitates communication and emphasizes breed maintenance (Sponenberg et al., 2014).

Biologic management of the breed involves managing the genetic diversity of the breed to assure long-term avoidance of inbreeding. This must be done by different strategies depending on the breed. For large animals of great individual monetary value, usually horses and cattle, it is often possible to rely on individual identification of animals and accurate pedigrees. As animal size and monetary value decrease, the individual identity of animals is likely to be less and less available. This is es-

pecially true in landrace situations that rely on multi-sire matings in traditional settings. It is ironic that these are the genetic resources with highest adaptability and also greatest genetic uniqueness. That makes them high priorities for effective conservation.

Managing extensively-raised landraces presents challenges, but creative thinking and breeder dedication can solve these. A few that are successful in the USA include the inspection of every registered animal (Navajo-Churro sheep), and also the flock-based ideas behind the Gulf Coast Sheep Alliance. This group has minimal formal organization, but does have a short list of requirements for inclusion into the group. These include:

1. No other breeds of sheep are to be kept on the same property as the Native flock. This is because crossbreeding is too likely when multiple breeds are kept, and recognition is by flock rather than by individual sheep. Sheep recognized as "Native" by the Alliance are those registered as Gulf Coast Natives by that association, or those coming from a Native flock as described by the Alliance.

2. A brief history of the flock is written and kept on record by the Alliance. This includes sources of sheep, their origin, and approximate dates.

3. Any later additions to the flock are noted as to source flock, year, and sex of addition. Ideally additions will only come from flocks recognized by this Alliance or individual sheep registered by the Gulf Coast Native Sheep Association.

4. Each flock participant will give an annual update on approximate numbers of sheep and sources of any additions to the flock.

5. In cases where breeders have divided their sheep into separate flocks for breeding to maintain different lines, these should be noted and tracked.

Even this level of record-keeping may be impossible in some situations, especially in peripheral underdeveloped regions where literacy is rare. Organizing breeders and valuing the local resource can still encourage purebred breeding in that situation, and needs to be done to the extent possible. Even in illiterate situations individual animals are recognized, and this often includes their relative level of purity. Traditional knowledge and production systems can be effectively used for conservation, and can empower traditional communities in positive ways. Local knowledge and empowerment are essential for success.

Sustainable livestock breeds also usually involve effective associations of breeders. In the past, isolation could assure purebreeding and breed identity, but increasingly the barriers of isolation are reduced and more formal and deliberate associations can help to assure that breeds are maintained in the purity that assures their genetic integrity. Effective association is inclusive, and also facilitates the participation of both the older traditionalist breeders alongside younger and potentially more innovative breeders. Blending these two extremes together in a way that maximizes the contributions of both is a delicate balance, and is essential to success. Without the traditional breeders (who tend to be very conservative) the breed has no past, but without the recruitment of younger breeders (who tend to be more innovative) it has no future. Both are essential to success.

The organization of breeders affects the biological management of the breed, because communication and exchange of stock among breeders affects the biology of the breed. Due to this interaction of breeder organization and biological management they work together, and cannot be neatly separated into two separate issues. Without a functioning organization of breeders it is nearly impossible to have good biological management of landraces, and without good biological management an organization of breeders becomes meaningless.

Strong market demand for the breed's products also is essential for sustaining purebred populations of landraces. This is a challenge that can increasingly be met by appeal to the traditional products and production methods associated with local landrace breeds. In many cases these products will have unique flavors or textures that are favored by traditionalists. In other situations the products may be more generic, but may still have advantages that come through their association with a specific region or production method.

Sustaining populations also involves measuring production levels of the animals. This is more complicated than it might seem, because different measures lead to different outcomes. Measuring the production levels of individual animals nearly always benefits larger animals. Measuring the production of animal product per unit area (hectare) tends to benefit traits like longevity and adaptation, and may well diminish the size of individual animals while increasing overall productivity of the agricultural enterprise. Designing systems to effectively measure the productivity that most benefits the owners is a key to success, and is often a key to highlighting the benefits of adapted local livestock over imported trans-national breeds.

CONCLUSION

Effective breed conservation is a delicate balance of many different factors. Several of these are biologic, and involve issues of breed definition and maintenance. Equally important are social and economic aspects, because only when these are successful can the breed survive as a productive and meaningful component of an agricultural system.

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