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ORIGINAL PAPER

# Fit for purpose – the right animal in the right place

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**Abstract** The development pathway for tropical livestock production for many years in the twentieth century was to upgrade or replace indigenous stock with exotics of supposedly higher genetic merit. Early indications that this might not be the most appropriate approach were largely ignored. Later there was a reverse movement towards locally developed species and breeds. These were seen as pools of irreplaceable genetic material of unacknowledged merit and value that must not be lost but must be conserved for possible unknown unseen future use. This paper examines the use of various native species and breeds. It goes on to describe some attempts at the introduction of genetically engineered highly productive (at least in their areas of origin) stock. Examples of attempts to produce cross or synthetic breeds are then provided. In a last section the case for the right animal in the right place - and these may be unconventional species and breeds - is provided.

**Keywords** Adaptation · Domestic animal genetic resources · Production systems · Single purpose breeds · Crossbreeding

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## Introduction

Finely tuned, genetically engineered, highly productive animals that need large quantities of top quality inputs and high calibre management may not be best fitted to many tropical environments. The "development pathway" for much of the twentieth century was, nonetheless, to upgrade or replace indigenous animals with such breeds. This was in spite of early indications that success may not be achieved (French 1941). From the 1970s a weak undercurrent nudged the conservation or preservation of native breeds but this mainly flowed in the richer and developed countries via, for example the Rare Breeds Survival Trust in the UK (Alderson 1990) and the American Livestock Breeds Conservancy in the USA (Sponenberg and Bixby 2007). There was later interest - much of it of an academic nature - in the developing countries in conservation of indigenous livestock (Burfening and Juan Chavez 1996; Pundir et al. 1996; Mpofu 1996; Rege 1999). These types of domestic animal have now come to be known as "animal genetic resources" and have been dignified with the catchy acronym, AnGR (see, for example, FAO 2007). In spite of many years of discussion, however, the major issues have still not been resolved. The questions for research and development are should they:

> seek to preserve or conserve the unique survival mechanisms of indigenous livestock;

concentrate on single purpose breeds and intensified production; or
take a middle approach that contains elements of both these paradigms?

## Native and adapted livestock

Many native tropical breeds are not only dual- but multi-purpose. They are expected to produce milk, plough, pull carts, give blood, provide wool and, at the end of their lives, provide meat to feed and hides or skins to clothe their owners. They do all this on resources at which specialized breeds would turn up their muzzles with disgust. The capacity to utilize low quality feed and convert it to protein for human use must not be lost by the livestock of the tropics.

Fitness characters of tropical livestock not or possessed to a lesser degree by temperate breeds include:

- a lower metabolic rate that generates less heat;
- reduced panting but more ready sweating that conserves energy;
- a feed intake less affected by high temperatures;
- a higher intake of poor quality feed;
- higher digestibility and efficiency of feed conversion;
- lower water requirement;
- a greater ability to retain feed and water in the large intestine, and
- better resistance to ticks, insects and some diseases

A report commissioned by the British Colonial Office concluded that "the consensus of opinion [is] that, under existing conditions of environment, concentration on the selection of indigenous breeds is, generally speaking, the soundest policy" (Faulkner and Brown 1953). The consensus resulted from improved output of native animals. From 1930 to 1960 these improvements largely resulted from better management and feeding rather than selection and progeny testing which were techniques then in their infancy.

One example of improvement in dairy production is Nandi cattle in Kenya. The average yield of foundation cows in 311 lactations was 580 kg whereas that of their progeny was 1037 kg in 355 lactations: during the same period lactation length increased from 182 to 252 days and calving interval fell from 13.0 to 11.7 months. At Shambat in the Sudan a herd of Kenana cows, 12 years after its foundation, had a lactation yield of 2100 kg in 288 days and an average daily yield of 7.3 kg (Alim 1960). In an Indian Sahiwal herd milk output increased from 3.3 to 8.3 kg/cow/day between 1913 and 1935. Maximum yield was 4200 kg with averages in excess of 2000 kg in a 300-day lactation. This increase was partly achieved by management and nutrition and partly by culling of poor producers and selection of high yielding lines (Ogilvie 1947).

Some indigenous cattle are suited to beef production. Even with these animals, however, better management, improved nutrition and adequate veterinary care are important first steps for rapidly raising productivity. Supreme among tropical beef breeds are Boran in Kenya and Ethiopia (Haile Mariam et al. 1998; Homann et al. 2005), Mashona and Tuli (Ward and Tawonezvi 1983; Harvey 1987; Moyo 1990; Khombe 1995; Homann et al. 2005) in Zimbabwe and Botswana and Nelore (also known as the Indubrasil and originally called Ongole in its native India) and the Criollo-derived Caracú in Brazil (Cardellino 2000). The Brahman, usually associated with the southern states of the USA but originating from India (although mainly coming directly from Brazil), is an outstanding example of a tropical beef animal finding a niche in a harsh environment (Table 1).

Other tropical cattle types have been bred for draught or pack. The Afrikander is perhaps the best known, originally being developed to pull the heavy Voortrekker waggons of the South African Boers. The

**Table 1** Improvement in production of Brahman cattle over seven years in Venezuela

| Trait | Year | | Improvement (%) |
|---|---|---|---|
| | 1 | 7 | |
| Weaning rate (%) | 43 | 73 | 70 |
| Weaning weight (kg) | 142 | 167 | 18 |
| Weaned calf per cow (kg) | 61 | 122 | 100 |
| Survival to 18 months (%) | 36 | 68 | 89 |
| Weight at 18 months (kg) | 256 | 319 | 21 |
| Weight of 18 month calf/cow (kg) | 92 | 211 | 129 |

Source: adapted from Plasse 1992

Haryana breed and the Kankrej and Nagore from India are strong, fast draught animals.

Indigenous goats of high productivity are the Boer from South Africa and the Damascus of the Near East. The Boer goat was developed in South Africa in the early 1900s for meat production. It was probably bred from the indigenous goats of the Namaqua Bushmen and the Fooku tribes with some possible infusions of Indian and European bloodlines. Selective breeding has resulted in a docile goat of good fertility with a fast growth rate, heavy mature weights (males 110–135 kg, females 90–100 kg) and an excellent carcass. These qualities make it one of the most popular meat breeds in the world. Boer goats have a high resistance to disease and adapt well to hot and dry environments (SASBA 2004). The Damascus goat is a native of Syria and Lebanon but has been most developed in Cyprus. It is a rather large breed with an adult live weight of about 65 kg in females and 75 kg in males. It is reputed as a dairy animal with meat as a secondary product. Fertility is 80 to 90 per cent which is characteristic of most goat breeds with high milk production. Prolificacy, however, is high and averages 1.80 kids per doe kidding so that annual production of young averages about 2.5 per year. Total milk production ranges from 350 kg to 730 kg per lactation (Table 2) of which 190–240 kg is suckled by the kid(s) with 200–350 kg taken off for commercial purposes after weaning. Lactations extend from five to nine months following weaning although lactations may extend to one year. Fat is in range 3.8–4.5 per cent and protein 4.0–4.8 per cent (Mavrogenis et al. 2006). Many other indigenous goats could be cited, including the Jamnapuri and Black Beetal of India.

Among tropical and sub tropical sheep, the Chios and the Awassi of the Near East are excellent producers of milk. The Sudan Desert is a dual purpose milk and meat animal. The Chios, native to the homonymous Greek island but used throughout the eastern Mediterranean and Near East regions, is a fat-tailed medium sized sheep with rams weighing up to 90 kg and ewes up to 70 kg. The breed is early maturing and can be mated at 8–9 months. It is also a non-seasonal breeder that is capable of two lambings per year. Average litter sizes im mature ewes are in the range 1.5–2.3 lambs. Milk production is generally 120–300 kg per lactation although exceptional animals produce up to 600 kg in a 270 day lactation. Fleece weights are in the range 1.2–2.5 kg but overall quality is rather poor (Mason 1980; Hatziminaogiou et al. 1990). The Awassi sheep - whose name is attributed to the El Awas tribe between the Tigris and Euphrates rivers in Iraq - is the most numerous and widespread breed of sheep in the Near East and is the classic multipurpose animal. In Syria, for example, the Awassi contributes 30 per cent to national milk production, 78 per cent to meat and 100 per cent to wool Fat-tailed sheep have been bred here for at least 5000 years and have become fully adapted to the subtropical semiarid or arid environment. Traditional (Bedouin) flocks are kept in the open day and night throughout the year and depend entirely on natural feed resources and crop residues for sustenance and production. The unimproved Awassi is a robust and vigorous medium-sized sheep whose bodily proportions are affected by the size and weight of the fat tail. Rams weigh 60–90 kg (of which the tail may be 12 kg) and ewes 30–50 kg (tail 6 kg). In improved dairy types rams may exceed 100 kg and ewes range from 60 kg to 70 kg. Fertility in traditional flocks is 70–80 lambs per 100 ewes (with less than 5 per cent twins) but in experimental flocks with superior feeding and maintenance higher rates of 110–120 have been recorded. Annual milk yield in unimproved flocks is estimated at 40 kg exclusive of about 20 kg taken by the lamb. In an experimental flock in Lebanon average yields in six consecutive lactations were 197 kg to 231 kg with maximum yields of 268 kg to 406 kg. Very high average yields in excess of 400 kg have been recorded in Israel but 1100–1300 kg per lactation are not uncommon in the very best flocks. As for most sheep the fat content of up to 7.5 per cent is high. With its characteristic conformation and large accumulation of fat in the tail the Awassi is far from the classic mutton sheep proper yet

**Table 2** Milk production and prolificacy of Damascus (Shami) goats on a private farm in Cyprus

| Year | Milk yield (kg) | | | Kids per female per year | | |
|---|---|---|---|---|---|---|
| | No | Mean | +/− s.d. | No | Mean | +/− s.d. |
| 2000 | 102 | 640.4 | 106.2 | 102 | 2.62 | 0.83 |
| 2001 | 334 | 668.0 | 100.6 | 336 | 2.39 | 0.77 |
| 2002 | 386 | 708.5 | 114.5 | 387 | 2.36 | 0.75 |
| 2003 | 459 | 731.9 | 144.0 | 459 | 2.27 | 0.73 |

Source: Mavrogenis et al. 2006

mutton and lamb from this breed are highly appreciated throughout its range. In Syria in 1995 Awassi mutton sold at about 35 per cent more than beef. Fattened Awassi lambs weighing 60–70 kg before slaughter have a carcass yield of approximately 50 per cent of which 45 per cent is muscle, 43 per cent is fat and 11 per cent is bone. The wool is long with an open moderately lustrous fleece of carpet type with distinct wide crimps. Unimproved rams have fleece weights of 2.0–2.5 kg and ewes 1.75 kg whereas in improved types ram fleeces are about 4.3 kg and ewe fleeces up to 3.0 kg although in sheep selected for wool yields can be much higher (Mason 1967; Epstein 1982; Amin and Peters 2006).

## Intensive production from modern single purpose breeds

By the 1960s the winds of change were blowing over the tropics in more than one sense. There were policy changes in many countries about the value of indigenous livestock and especially the speed at which genetic progress could take place to improve them. Since then, modern single purpose breeds and modern methods of husbandry have penetrated remote parts of the developing tropics just as the plants of the Green Revolution did before them. Dairy cattle, for example, were taken to Tanzania, Kenya, Nigeria and Ghana in Africa. In the tropics of South America, Holstein Friesian and Brown Swiss were imported in large numbers (Vaccaro 1984). Many of these imports had no hope of success and even though exotic breeds may initially have had higher yields than the indigenous animals they soon fell behind (Aboagye 2002). Many imports also had more to do with politics than animal production and reflected the changing links between the developing countries, the former colonial powers and the new partners that were the socialist states. In Ghana from 1942 Jersey cattle were imported from the United Kingdom and then Russian Black and White in the immediate post-Independence period of Nkrumah socialism. Holstein Friesians were later imported from Canada, the United Kingdom and the Netherlands as were Brown Swiss from Austria but, although there was some initial "success", none of the programmes could be sustained (Kabuga 1989).

Goats and sheep are not exempt from the fashion for exotic breeds being exported and implanted in less than ideal conditions. German, Finnish, Norwegian and other northern European animals struggle to survive in torrid conditions for which they are totally unadapted. French, Italian and Swiss goats do little better. The general situation is that exotics do well during the period that a "project" is active and external supervision (and even hands-on management) is in operation. Success is usually measured in terms of milk produced for goats and increases in household income. There is hardly ever, however, a full cost benefit analysis which takes into account the opportunity cost of labour and loss of land that is transformed from food to feed production. Once direct support is terminated it is only a matter of time before the exotics disappear and the indigenous breeds come back into their own.

Reasons for the failure to establish highly productive enterprises in the tropics with exotic livestock include:

- high import costs;
- heavy mortality;
- poor fertility;
- reduced appetite due to high temperature and humidity;
- low quality pasture;
- susceptibility to internal and external parasites; and
- inadequate management skills.

There have been some limited successes in the introduction of animals of "superior genetic merit". These have often, however, been achieved at huge financial and environmental cost. Where projects of this nature have been successful it has been under special conditions. Thus European dairy breeds can produce and reproduce well in some highland tropical areas such as parts of Kenya and South America and in some subtropical areas like Zimbabwe where climatic and other environmental conditions are less severe, where good management is possible and where there can be regular renewal of the high grade stock (Fig. 1). The use of AI can lead to maintenance of dairy strains (Connelly 1998) but the power of some large international breeder organizations often means that even within this restricted setting inappropriate breeds are the most numerous. In Kenya, for example, the Holstein Friesian is much more numerous than the Ayrshire, Jersey and Guernsey which are its "competitors" but performs least well in many

**Fig. 1** Purebred Jersey cows under intensive management in Zimbabwe, 2000

financial and production traits (Ojango and Pollott 2004). Projects that promote pure exotic breeds have often lost enormous sums of money and most if not all of their animals. In Mauritania in 1990, for example, a group of newly imported Friesians suffered disastrously from an outbreak of lumpy skin disease while local cattle in close contact were unaffected (Davies 1991).

Livestock development programmes have failed because of inappropriate technology. That technology often equates to exotic livestock breeds and intensive systems of feeding and management under conditions where there are frequent breakdowns in electricity supply, lack of spare parts for air conditioners and other equipment and interruptions in the imported feed supply. Yet, there is often no need to supplant local farming systems with imported ones. The efficiency of the existing ones should be improved, including especially those in which livestock convert crop residues to draught power, dung, meat and milk.

## Crossbreeding and synthetic breeds

Crossbreeding of exotics with indigenous stock has been widely practised in attempts to improve the supposedly low productivity of the latter. This takes place in spite of the facts that fuller knowledge of traditional and native breeds and evaluation of their production potential have yet to gained.

Some progress has been achieved with crossbreeding and with stabilized synthetic breeds. This approach - as for single purpose breeds, is nonetheless likely to be more successful where adequate health care, nutrition and management can be assured. The Australian Milking Zebu (AMZ), developed in the 1950s and 1960s with especial reference to heat tolerance, tick resistance and milk production is an example of the latter. It is a cross of Sahiwal and Red Sindhi bulls on Jersey cows and yields over 2100 kg of milk per lactation at 4.5 per cent fat (Stephens 2006). A more recent development is the Australian Friesian Sahiwal (AFS) that considered better than the AMZ which it out-yields by 18 per cent and has higher fertility in the wet tropics of Australia (Stephens 2006). Production by AMZ animals exported to Trinidad was less good because management was poor.

Another Caribbean development is the Senepol (Fig. 2). Trypanotolerant N'dama cattle from West Africa were imported into Martinique and Guadeloupe in 1825 and to the American Virgin Islands between 1870 and 1914. At St Croix in the latter island group they were crossed with Red Poll cattle in the early 1900s and the resulting progeny became known as Nelthrop (after the main propagator of the breed) or Senepol. According to the Breeders' Association the Senepol combines N'dama traits of heat tolerance and insect resistance with the Red Poll's extreme gentleness, good meat quality and high milk production. Senepol were also selected for early maturity and maternal efficiency, no horns, solid red colour, definite heat tolerance and gentle disposition. The isolation (of St Croix) "sheltered the cattle from the fads and fancies of the purebred seedstock industry. While other breeds made giant leaps in one direction, only to turn and make equally large strides in the opposite direction, the Senepol made a series of

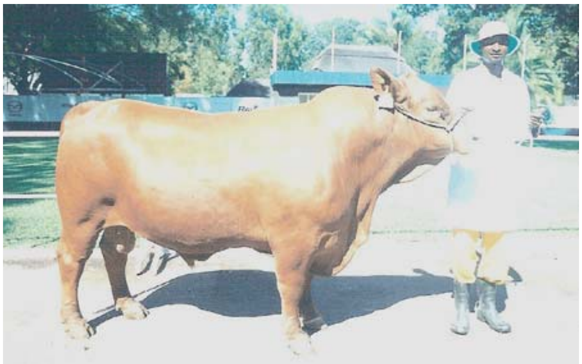

**Fig. 2** Senepol bull at the annual sale of pedigree stock in Zimbabwe, July 2000

small, multiple-trait steps toward animals whose production met the demand of their breeders. St Croix provided a unique situation where ranchers practised selection for the traits they desired and mother nature provided natural selection for cattle that could produce at superior levels under the harsh St Croix environment" (SCBA 2008). Although the breed has spread far and wide it is rather small for beef production and at least some believe it has "only minor local importance [... and...] a herd exists on an experimental station on St Croix" (Hickmann 1991).

Some composite breeds, including the American Santa Gertrudis and the Australian Droughtmaster, are excellent producers of quality beef. Originally developed on the King Ranch in southern Texas in the 1920s/1930s the Santa Gertrudis is a fixed cross comprising 3/8 zebu and 5/8 shorthorn and has spread throughout much of the tropics and subtropics. It is reputed to be tolerant of heat and ticks. The Santa Gertrudis is used widely in Australia (Stephens 2006), southern Africa and Brazil. The Droughtmaster is similar to the Santa Gertrudis being a composite of about 50 per cent each of Brahman and Shorthorn with a touch of Devon. Developed from about 1910 in northern Queensland, the Droughtmaster is "Australia's Own Breed". It is reputedly docile, drought and heat tolerant, resistant to tick borne diseases, fertile, easy calving and provides good quality meat (Stephens 2006).

Jerseys have been used extensively for crossing in the tropics and seem more adapted to hot environments than many other *Bos taurus* animals. Jersey bulls were used in Costa Rica in Central America on the native Criollo milk breed. Results from F1 animals were good but were poorer from back crosses (Table 3). Part of the problem was that the Criollo does not "let down" milk in the absence of the calf. The trait is partially under genetic control and is affected by the genetic composition of the bulls but refusal to let down milk is unacceptable in commercial herds (de Alba 1987).

The Jamaica Hope is another example of the use of Jerseys. The breed is a cross of "native" cows of mixed zebu blood with Jersey bulls although Sahiwal bulls from India were used later. It was named after the Hope Stock Farm in 1952 and a breed society was formed (MoA 1972; Wellington and Mahadevan 1975). Bulls later came mainly from one herd which had an average lactation yield in the 1960s of 3220 kg and a calving interval of 431 days. As there were only a few herds and even fewer recorded ones, bull selection was hampered and there was insufficient culling. During the period 1969–1975 annual yield in 28 commercial herds declined by 32 per cent. The reduction was attributed mainly to poor management and feeding and a lack of enthusiasm by breeders (Schneeberger et al. 1982). In spite of an intrinsic capability for high yields the breed was not a success and failed to make other than a small impact in Jamaica.

**Table 3** Milk production by dairy Criollo, Jersey and their crossbreeds in Costa Rica

| Breed/cross | Number of lactations | Total yield (kg) | Lactation length (days) |
|---|---|---|---|
| Criollo | 1092 | 1504 | 256 |
| Criollo x Jersey | 296 | 2082 | 301 |
| Jersey x Criollo | 271 | 2022 | 307 |
| Criollo x (Criollo x Jersey) | 72 | 1645 | 266 |
| Jersey x (Jersey x Criollo) | 117 | 1888 | 290 |
| Jersey | 345 | 1883 | 301 |

Source: adapted from de Alba 1987

Cross breeding with the intention of producing a synthetic dual purpose breed of cattle suitable to Tanganyika [Tanzania] conditions was started at Mpwapwa in the 1930s (DVSAH 1937). The Tanganyika Shorthorn Zebu was used as the base. The intention was to retain 30 per cent of the genetics of this type in the final composite together with 60 per cent of Sahiwal and Red Sindhi and 10 per cent of Ayrshire (Syrstad 1990). Over the years there have been many changes in direction reflecting, all too often, the interests of the current researcher rather than the long term development of a truly fixed genetic type. Following the initial period Jersey, Guernsey and Friesian blood was introduced as was that of Boran, Ankole and Sahiwal. The current "breed" may be as much as 75 per cent Sahiwal (FAO 2005). This mish-mash of genetics has remained mostly on the station of its conception and local farmers have been largely uninterested in making use of it. In spite of clear lack of success public service researchers (and international organizations) have continued to spend good money on its "development" whilst concurrently lamenting its imminent demise.

The Dorper sheep (Fig. 3), a synthetic breed derived from the British Dorset Horn and the Persian Blackhead in South Africa, is one of few examples of sustained success in small ruminant development. From its local origins it has been exported to Australasia, the Americas and the United Kingdom where its lack of wool and high prolificacy and rapid growth rates are much valued.

Not all crossbreeding in small ruminants has been so successful. In Rwanda (Central Africa), crossbred Anglo-Nubian and Alpine goats were not more productive, on a comparative basis, than the native Small East African type (Table 4). The Anglo-Nubian genotype was much worse. The crosses cost a large amount of money for repeat importations and for feeding and were not acceptable to the local population due to their larger size, increased need for supplementary feed and susceptibility to disease (Wilson and Murayi 1988). In spite of these facts, decision makers in Rwanda continue to opt for exotics and receive financial and technical help from the international community to import them.

Similar problems have arisen in attempts to improve scavenger poultry. The most common method is a cock exchange scheme in which exotic males are swapped for local birds. Improvements should occur in size - and thus meat output - and egg production. The result is usually that the exotic bird and the first cross offspring are lost. They are unable to cope with the more aggressive native birds, succumb to disease and adapt badly to having to scavenge for food (Kuit et al. 1986).

Maintaining crossbred populations with well-defined proportions of blood of the parent breeds is neither simple nor a long term solution in most tropical areas. One authoritative source believes there is “little evidence to suggest that the new breeds produced in Latin America and the Caribbean for beef production are more efficient than zebu cattle when maintained under ranch conditions. Continuous cross breeding programmes do result in increased efficiency of production but produce considerable management problems of which the maintenance of bulls of European beef breeds in the ranch situation is not the least. While not insurmountable these will ensure the continuing paramount importance of pure zebu breeding for beef production for many years” (Hickmann 1991). The scarcity of protein-rich feed so essential to high productivity is often a major limitation. The needs and problems of small farmers with one or two animals, restricted financial and technical resources and lacking adequate extension advice must not be forgotten. Large quantities of milk or meat produced at a cost higher than the sale value are neither sustainable nor the way forward. “High quality” stock have to compete with local adapted animals producing at less financial and much lower opportunity costs.

**Fig. 3** Dorper sheep, a fixed crossbred on open range in the Kalahari desert in Botswana

**Table 4** Comparative performance of Small East African goats and crossbreeds in Rwanda

| Parameter | Breed | | |
|---|---|---|---|
| | Small East African | Anglo-nubian x SEA | Alpine x SEA |
| Age first kidding (days) | 598 | 766 | 537 |
| Kidding interval (days) | 323 | 384 | 323 |
| Young per birth | 1.78 | 1.82 | 1.66 |
| Deaths to 150 days (%) | 16.0 | 26.3 | 11.2 |
| Birth weight (kg) | 2.35 | 2.68 | 2.89 |
| 150 day litter weight (kg) | 14.5 | 16.9 | 18.8 |
| Mature weight (kg) | 37.5 | 51.1 | 42.1 |
| Index (wt of young/kg of dam (kg)) (kg) | 0.46 | 0.35 | 0.51 |

Source: Wilson and Murayi 1988

The possibilities of crossbreeding are encouraging in some areas but there are limitations to the extent to which it can be exploited. Successes have been achieved, for example, in the highlands of eastern Africa and especially in Kenya with Ayrshire, Friesian, Jersey and Guernsey cattle crossed on native zebu animals (Bebe et al. 2003). Management, health care and nutrition need, however, to be kept to a high standard if crossbred animals are to perform adequately.

## The right animal in the right place

Food production systems in developing countries are moving into marginal areas for which sustainable farming systems and the most adapted species and breeds of livestock have yet to emerge. These must be developed whilst paying due attention to the environmental, economic and equity aspects of the ecosystem. In the tropics the right animal is not always the one that produces the most. It might not even be a “conventional” species or breed. In the Bolivian Andes the Guinea pig (Valle Zárate et al. 1994) is best suited to peasant families with limited labour and access to little in the way of feed resources (Fig. 4). In Fayoum oasis in Egypt it is the buffalo that provides milk and draught power (Fig. 5). In Peru and Chile the alpaca is the right animal for the highest altitudes at more than 4000 metres above sea level. In Ethiopia camels and mules work at altitudes of 150 metres below sea level to more than 3000 metres above it in the transport of salt (Wilson 1977).

One rather unusual example of an animal being bred for the right place at the right time, and incidentally also an indication of the knowledge and capacity of traditional owners, is that of the Barka people in Eritrea. The Barka bred their cattle for centuries for milk production and docility. In recent times, however, the second trait has been a disadvantage in the unsettled conditions of a war-torn country so the Barka desired an animal more suspicious of and less tractable to strangers. In order to produce such an animal they outcrossed their stock to the Dohein breed, an animal noted for its suspicious nature, from nearby Sudan. The result for the Barka is a beast that is less easy to control, needs more labour for herding and when being taken to market and that produces less milk than the original purebred. These inconveniences are considered worthwhile, at least for the present, in the reduction of losses due to theft (Fre 1991; Dinucci and Fre 2003).

**Fig. 4** Guinea pigs in a smallholder system in Cuzco, Peru

**Fig. 5** Buffalo, a source of milk and draught power in Fayoum oasis in Egypt

In parts of India attempts to improve milk production of cattle have not been successful. This is because the cow is used mainly for draught and the buffalo is the dairy animal although the “net efficiency” of buffaloes for draught is 39 per cent compared to 29 per cent for cattle. The right animal in this production system is the buffalo and improvement of its productivity should have priority over that of cattle.

Elsewhere the yak or the camel might be the right animal. The first is superbly adapted to its cold damp environment and the second to its hot arid one. Both produce fair amounts of milk on little and poor quality feed. Yak milk is high in fat and is thus an excellent source of energy for its owners. In Israel attempts have been made to improve camel milk production by intensive management and by providing a balanced diet (Yagil et al. 1994). High yields are claimed in the context of an animal that can still withstand the rigours of a desert climate and the camel is promoted as the right animal in the right place. Not everyone agrees with this as it is unlikely that the improvement is transferable and is almost certainly not sustainable in the camel's natural milieu. Intensive management and irrigated green feed remove the animal from its environment and degrade that environment by the use of scarce resources. The camel has a comparative advantage on poor quality feed, in its need for small quantities of water and in its ability to trek long distances in search of these two resources. Attempting to treat it as, and making it compete with, a cow puts it at a comparative disadvantage and it cannot be considered the right animal in that context.

There have been attempts to introduce livestock and especially cattle into systems with no tradition of keeping the species, where adequate feed is lacking, and where labour is in short supply. Some agricultural communities in humid central Africa represent this scenario. In this situation the right animals to increase human dietary protein through consumption of more meat and milk are goats and, to a lesser extent, sheep. Poultry also provide meat and eggs. These species are the right animals in this environment because people are not afraid of them due to their size, they scavenge well for their own feed and complement each other in feed requirements. Women and children can provide the labour to look after them and can also benefit directly from the consumption and sale of their products.

In summary the qualities required of the right animal in the right place, if it is to succeed, are:

- adaptation to local physical, nutritional and management environments;
- acceptability to local people;
- resistance to the common diseases of the area;
- good reproductive and growth performance; and
- adequate yields of meat, milk, draught power and other products in relation to the prevailing management system, feed availability and veterinary services

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