

Livestock sustainability and animal welfare.

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ABSTRACT

Sustainable animal production systems are urgently needed. A system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, in particular in relation to resource availability, consequences of functioning and morality of action. What might make an animal usage system unsustainable? The system might involve so much depletion of resource that it will become unavailable. Alternatively, a product of the system might accumulate to a degree that prevents the functioning of the system. However, any effect which the general public find unacceptable makes a system unsustainable. A production system might be unsustainable because of: inefficient usage of world food resources; adverse effects on human health; poor welfare of animals; harmful environmental effects such as low biodiversity or insufficient conservation; unacceptable genetic modification; not being “fair trade” in that producers in poor countries are not properly rewarded; or damage to rural communities. Any of these inadequacies could result in the quality of the product being judged as poor. Animal welfare and other aspects of sustainability are better than the average in animal production when pigs exploit woodland. Three-level plant production, including pasture, shrubs with edible leaves and trees that may also have edible leaves are an example of a silvopastoral system. The production of leaves and other material that can be eaten by the animals is much greater than can be achieved by pasture-only systems. Results presented from tropical and sub-tropical studies show that cattle production can be better, biodiversity much increased, animal disease reduced, and animal welfare also improved by better availability of shade and other conditions selected by the animals. There are also possibilities for feeding tree and shrub leaves to pigs, poultry or farmed fish.

Key words: animal welfare, disease control, livestock, silvopastoral, sustainability,

Changing ideas about sustainability

The meaning of the term sustainable is now much wider than it was. Systems were initially called unsustainable when a resource became depleted so much that it became unavailable to the system, or when a product of the system accumulated to a degree that prevented the functioning of the system. Now the meaning of the term is much wider, for example a system can be unsustainable because of negative impacts on human health, animal welfare, or the environment. A definition of sustainability is: a system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, in particular in relation to resource availability, consequences of functioning and morality of action (modified after Broom 2001, 2010). The development of new, sustainable systems is urgently needed because the public is becoming better informed about the negative consequences of some industrial and livestock production practices. Consumers now include the ethics of food production in their evaluation of product quality (Broom 2010).

What might make an animal usage system unsustainable? Any effect which the general public find unacceptable makes a system unsustainable. Members of the public in all parts of the world, particularly in developed countries, are now insisting on transparency in commercial and governmental activities and on changes in methods of producing various products. A production system might be unsustainable because of: inefficient usage of world food resources; adverse effects on human health; poor welfare of animals; harmful environmental effects such as low biodiversity or insufficient conservation; unacceptable genetic modification; not being “fair trade” in that producers in poor countries are not properly rewarded; or damage to rural communities. Any of these inadequacies could result in the quality of the product being judged as poor. In

future, consumers are likely to demand that sustainable systems are used. If they are not, retail companies, production companies and countries that do not produce good quality, sustainable products are likely to be boycotted and hence forced to change (Bennett et al 2002, Broom 2014).

Efficient use of world resources

What can be done in animal production to exploit existing resources better? The most important animals for food production are those that eat food that humans cannot eat. Hence herbivores eating forage plants, not cereals, are much more important than pigs or poultry which compete with humans for food. Similarly, herbivorous fish are more important than those fish that eat other fish.

Maintaining resources, such as soil with good structure, and retaining water that might be lost from the soil are important objectives, as are minimising usage of carbon-based energy and imported fertilisers.

Adverse effects on human health

Some foods are regarded as being better for the health of the consumers because of the nutrients present in them. A major effect of such attitudes on animal production in recent years has been the dramatic increase in the production of farmed fish, in part because they contain poly-unsaturated fats. As open water fish management has failed in most parts of the world, fish-farming has increased and is likely to increase further. In future, herbivorous fish are likely to be the most important species and the welfare of fish and impact of farms on the environment will have to be fully considered for there to be public acceptance of the products.

In all aspects of farming, antibiotic use will have to decrease, in most countries via legislation. This is because of the development of antibiotic resistance, largely because of human misuse of antibiotics but partly because of widespread rather than just therapeutic use in livestock farming.

Harmful environmental effects

Poor welfare of animals is probably the third most important reason for unsustainable livestock production but is considered in more detail in section 8. Agricultural methods that result in low biodiversity and the need for conservation are perceived to be the norm by many of the general public. However, biodiversity on farmland can be much increased in some systems. Livestock production can also result in pollution, locally and on a world-wide scale, e.g via greenhouse gas production. Greenhouse gas production may have to be balanced against efficiency of use of world resources.

Unacceptable genetic modification

Large sections of the world public are unwilling to accept the use of genetically modified plants and few people accept the use of genetically modified or cloned animals. One reason for this is dislike of modifying what is natural. Another is that modified organisms may have allergenic proteins and many of the public do not believe that proper checks on such possibilities are in place. Animals which are genetically modified may be more likely to have welfare problems so there should be checks using a wide range of welfare indicators before they are used for any purpose.

Not being “fair trade”

In recent years, consumers in many countries have been appalled to find that producers of food in poor countries are often not properly rewarded for their work and that most profits go to large companies. Now, products like coffee, cocoa and fruit are among those that are independently checked and have a Fair Trade label.

Damage to rural communities

When small-scale rural farmers are out-competed by large-scale production, local communities may disappear. The general public often find this unacceptable so schemes are introduced by governments to safeguard such communities. Consumers may also buy locally-produced products, regarding this as a part of product quality. In the European Union, subsidies to preserve rural communities have prevented large cities from becoming ever larger.

Negative impacts on animal welfare

Welfare is the state of the individual as regards its attempts to cope with its environment (Broom 1986) so can be measured scientifically. Measures of animal disease are often important because health is a key part of welfare. Other measures, for example of behaviour, physiology, immune system function, body damage, etc. are described by Broom (2014) and Broom and Fraser (2015). The welfare of animals kept on pasture-only systems can be poor because of heat-stress, parasitic and other infectious disease and low nutrient availability with associated competition (Petherick 2005). The welfare of animals in feed-lots is often worse than that of animals on pasture.

Sustainable systems and welfare: livestock in woodland

Agroforestry allows the use of spaces or clearings in woodland for livestock. The animal production is additional to woodland production and may have benefits when dung components are utilised by the plants. Animal welfare and other aspects of sustainability are better than the average in animal production, for example when Andalusian or Portuguese pigs exploit woodland. The trees may be chestnut, oak, etc. and the pigs eat the fruits of the trees, either when these are produced or later. Agroforestry produces wood, as well as meat or other animal products (Tirapicos Nunes 2007, Santos Silva and Tirapicos Nunes 2013), and often provides an environment that results in good welfare for the animals.

The woodland may itself be made up of trees planted for production of a human resource. For example, in Malaysia cattle can utilise areas between trees in oil-palm plantations. Agropastoral combinations of soya or other crops and cattle can have various benefits. However, we have little knowledge of the effects on animal welfare.

Sustainable systems and welfare: silvopastoral three level systems

Three level plant production, including pasture, shrubs with edible leaves and trees that may also have edible leaves are an example of a silvopastoral system. A cattle production system whose characteristics and aims include: using three-level or other multi-level production of edible plants, managing the soil taking account of worms and water retention, encouraging predators of harmful animals, minimising greenhouse gas emissions improving job-satisfaction for stock-people, reducing injury and stress in animals and maximising good welfare, considering how to encourage biodiversity using native shrubs and trees, and utilising the potential for obtaining wood from trees is explained by Murgueitio et al (2008, 2011), Giraldo et al (2011), Naranjo et al (2012),

Broom et al (2014). Examples of the plant species used are listed in Tables 1 and 2. Some of the trees are used as “live fences” (Grande and Maldonado 2011, Nahed-Toral et al 2013). There are also possibilities for feeding tree and shrub leaves to pigs, poultry or farmed fish. Where shrubs and trees are too high for animals to reach, branches can be cut and fed to the animals.

Table 1. Tropical and sub-tropical shrubs and trees that are eaten by sheep, goats and cattle in South America

<i>Gliricidia sepium</i>	quick-stick, mata ratón
<i>Guazuma ulmifolia</i>	, bay cedar, guácimo
<i>Morus alba</i>	white mulberry, morera
<i>Leucaena leucocephala</i>	leucaena
<i>Brosimum alicastrum</i>	Maya nut, ramón
<i>Tithonia diversifolia</i>	tree marigold, botón de oro
<i>Trichanthera gigantea</i>	tricanthera, nacedero
<i>Erythrina edulis; E. poeppigiana,</i>	poroto, búcaro
<i>Boehmeria nivea</i>	ramie, ramio
<i>Cratylia argentea</i>	veranera
<i>Malvaviscus penduliflorus</i>	mazapan, resucitado

The production of leaves and other material that can be eaten by the animals is much greater in silvopastoral systems than can be achieved by pasture-only systems. Results from tropical and sub-tropical studies show that cattle production can be better. Three-level forage production produces more usable plant material than pasture only. Pasture plus *Leucaena* produced 29% more mass and 64% more protein than monoculture herbage-layer only systems. Nitrogen-fixing plants are used so less artificial fertiliser is needed. Animal production can be better on silvopastoral systems than on monoculture systems (Murgueitio et al 2011). Three-level silvopastoral systems generally have better

soil structure, better water retention and less soil loss (Murgueitio et al 2008, Broom et al 2013).

Table 2. Shrubs and trees that are used for forage for ruminants and pigs in temperate countries

<i>Castanea sativa</i>	sweet chestnut
<i>Castanea mollissima</i>	Chinese chestnut
<i>Quercus pyrenaica</i>	Pyrenean oak
<i>Quercus ilex</i>	evergreen oak
<i>Quercus suber</i>	cork oak
<i>Olea europea</i>	olive
<i>Alnus nepalensis</i>	Nepalese alder
<i>Sesbania sesban</i>	sesban
<i>Chamaecytisus prolifer</i>	tagasaste
<i>Robinia pseudoacacia</i>	black locust/frisia
<i>Sambucus canadensis</i>	American elder
<i>Helianthus tuberosum</i>	Jerusalem artichoke (herb)

Three-level silvopastoral systems have much greater biodiversity than monoculture, single-level systems. The number of species of birds increased by 200%, that of ants by 30% and there were also increases in the numbers of butterflies etc. There was less pollution run-off because of water-holding properties of soil, 30% less methane production per kg meat and better carbon sequestration. Workers on silvopastoral farms reported better job satisfaction. Some comparisons of systems are shown in Table 3.

Table 3. Summary of comparisons: monoculture and silvopastoral systems

	“Improved” monoculture pasture (M)	Three level silvopastoral system (SSP)
M.E. Mcal.ha ⁻¹	56.9	70.2
Crude plant protein tonne ha ⁻¹	2.5	4.1
Milk per cow kg day ⁻¹	3.5	4.1
Meat kg ha ⁻¹ year ⁻¹	183	821
Methane tonne of meat ⁻¹	208	128
Bird species	24	75
Anaplasmosis % of herd	25	<5
Fights % difference	+37	
Social licking % difference		+65
Social interactions in shade % difference		+57

(Summary of data from 9 studies in Colombia and Mexico.)

The welfare of animals in silvopastoral systems has been demonstrated to be better in various ways than that on pasture-only systems (Table 4, Broom 2015, 2016). The beneficial effects of shade are substantial in hot weather with cattle skin temperatures up to 4C lower than in pasture-only systems. High temperature increases water and energy loss and reduces foraging times in paddocks fully exposed to the sun. (Améndola 2013, Améndola et al 2015). Less sun exposure results in less sun-burn, less cancer and less photosensitisation.

Anxiety and fear, including fear of humans, can be reduced when partial concealment is possible. This leads to better human-animal interactions and easier handling (Ocampo et al 2011, Mancera and Galindo 2011). More choice of food in silvopastoral systems results in more control by each individual animal of its environment and so social behaviour is more normal, (Améndola et al 2015).

The increase in predators lowers the populations of ticks and injurious insects, such as horn flies, and hence reduces the incidence of diseases such as anaplasmosis, which has been shown to drop from 25% to <5%. Reduction in diseases also leads to reduced antibiotic use. The presence of nitrogen-fixing shrubs such as *Leucaena* improves animal nutrition and this, together with the better water-retention by the soil, reduces the likelihood of thirst and starvation. Feeding behaviour is improved at high temperature and humidity if the animals are in a silvopastoral system (Ceballos et al 2011). It may be that the improvement in dietary choice contributes to this beneficial effect (Manteca et al 2008).

Table 4. Summary of benefits of silvopastoral systems for animal welfare.

Nutritional improvement because of shrub and tree intake	Murgueitio et al., 2011
Thermal comfort resulting from more shade	Galindo et al., 2013
Less fear because of concealment	Ocampo et al., 2011
Health better because more predators of ticks and flies	Murgueitio and Giraldo, 2009
Body condition better because of nutrients, shade and less disease	Ocampo et al., 2011, Tarazona et al. (in prep.)
Food intake and social behaviour improved	Améndola 2013, Améndola et al., 2015
Better human-animal interactions	Mancera and Galindo, 2011

data from Broom et al (2013)

A study of welfare in three intensive silvopastoral systems was carried out in Colombia with *Leucaena leucocephala* and *Guazuma ulmifolia* as shrubs for browsing at more than 8,000 shrubs/ha and several tree species (Tarazona et al in prep). The needs of the cattle were met, there being good food and water availability, effective body

temperature control and physical comfort, good social behaviour and low parasite levels. Some respiratory infection occurred on one farm, but this might be expected by chance.

When the social behaviour of cattle was compared in a silvopastoral system and a pasture-only monoculture system in the region of Merida, Yucatán, Mexico there was more affiliative social behaviour in the silvopastoral system (Améndola 2013, Améndola et al 2013, 2015). Social licking was the main affiliative behaviour and was shown by 78% of the heifers in the silvopastoral system but only 47% in the monoculture system. In the silvopastoral system, 57% of interactions occurred in the shade. Head-butting and chasing occurred in the silvopastoral system but often did not develop into a fight. Social licking is known to occur after the animals have obtained food and shelter (Sato 1991) but it does reduce the heart rate of the participants (Laister et al 2011) and contributes to the stability of social relationships in cattle (Sato et al 1993).

Conclusions

1. In relation to animal production throughout the world, there will be increasing demand from consumers for more efficient use of world resources and the avoidance of adverse effects on human welfare, animal welfare and the environment.

2. Industry has to rapidly change policies relating to animal welfare and other aspects of sustainability. The animal production industry should be proactive.

3. For tropical and temperate livestock production: consider three-level silvopastoral systems, with shrubs and trees with edible leaves.

4. Animal welfare has been developing rapidly as a scientific discipline and the benefits of silvopastoral systems for animal welfare have been studied.

5. Summary of animal welfare benefits of three-level silvopastoral systems:

- Nutritional improvement because of shrub and tree intake;

- Thermal comfort resulting from more shade;
- Less fear because of concealment;
- Health better because of more predators of ticks and flies;
- Less risk of cancers and other diseases caused by too much direct sunlight;
- Body condition better because of nutrients, shade and less disease;
- Food choice, food intake and social behaviour improved;
- Better human-animal interactions.

References

- Améndola L 2013. Conducta social y de mantenimiento de bovinos (*Bos indicus*) en sistemas silvopastoriles. Master's thesis. National Autonomous University of Mexico (Mexico City, Mexico).
- Améndola, L., Solorio, F.J., Ku-Vera, J. C., Améndola-Massiotti, R. D., Zarza, H. and Galindo, F. 2015. Social behaviour of cattle in tropical silvopastoral and monoculture systems. *Animal*, 10, 863-867, doi:10.1017/S1751731115002475.
- Améndola, L., Solorio, F.J., González-Rebeles, C., Galindo, F. 2013 Behavioural indicators of cattle welfare in silvopastoral systems in the tropics of México. *Proceedings of 47th Congress of International Society for Applied Ethology, Florianópolis*, p.150. Wageningen Academic Publishers, Wageningen.
- Bennett, R.M., Anderson, J. and Blaney, R.J.P. 2002. Moral intensity and willingness to pay concerning farm animal welfare issues and the implications for agricultural policy. *Journal of Agricultural and Environmental Ethics* 15, 187–202.
- Broom, D.M. 1986. Indicators of poor welfare. *British Veterinary Journal* 142, 524-526.
- Broom, D.M. 2001. The use of the concept animal welfare in European conventions,

- regulations and directives. In Food Chain pp.148-151, SLU Services, Uppsala.
- Broom, D.M. 2010. Animal welfare: an aspect of care, sustainability, and food quality required by the public. *Journal of Veterinary Medical Education* 37, 83-88.doi : 10.3138/jvme.37.1.83
- Broom, D.M. 2014. *Sentience and Animal Welfare*. pp. 200, CABI, Wallingford.
- Broom, D.M. 2015. New directions for sustainable animal production systems and the role of animal welfare. In: *3º Congreso Nacional de Sistemas Silvopastoriles y VII Congreso Internacional Sistemas Agroforestales*, Iguazú, ed. P. L. Peri, 385-388. Montecarlo, Argentina: INTA.
- Broom, D.M. 2016. Sentience, animal welfare and sustainable livestock production. In *Indigenous*, eds K.S Reddy, R.M.V. Prasad and K.A. Roa, 61-68. Excel India Publishers: New Delhi.
- Broom, D.M., Fraser A.F. 2015 *Domestic Animal Behaviour and Welfare*, 5th edn. CABI, Wallingford.
- Broom, D.M., Galindo, F.A. Murgueitio, E. 2013. Sustainable, efficient livestock production with high biodiversity and good welfare for animals. *Proceedings of the Royal Society B* 280, 20132025. doi.org/10.1098/rspb.2013.2025
- Ceballos MC, Cuartas CA, Naranjo JF, Rivera JE, Arenas F, Murgueitio E, Tarazona AM 2011. Efecto de la temperatura y la humedad ambiental sobre el comportamiento de consumo en sistemas silvopastoriles intensivos y posibles implicaciones en el confort térmico. *Revista Colombiana de Ciencias Pecuarias* 24, 368.
- Galindo, F., Olea, R., Suzán, G. 2013 *Animal welfare and sustainability. International Workshop on Farm Animal Welfare*, São Pedro_SP, Brazil. <http://www.workshopdebemestaranimal.com.br/indexen.html>

- Giraldo, C., Escobar, F., Chará, J.A., Calle, Z. 2011. The adoption of silvopastoral systems promotes the recovery of ecological processes regulated by dung beetles in the Colombian Andes. *Insect Conservation and Diversity* 4, 115-122. doi: 10.1111/j.1752-4598.2010.00112.x
- Laister, S., Stockinger, B., Regner, A.M., Zenger, K., Knierim, U., Winckler, C. 2011. Social licking in dairy cattle: Effects on heart rate in performers and receivers. *Applied Animal Behaviour Science* 130, 81-90.
- Mancera, A.K., Galindo, F. 2011. Evaluation of some sustainability indicators in extensive bovine stockbreeding systems in the state of Veracruz. VI Reunión Nacional de Innovación Forestal p. 31, León Guanajuato, México.
- Manteca X., Villalba J.J., Atwood, S.B., Dziba, L., Provenza, F.D. 2008. Is dietary choice important to animal welfare? *Journal of Veterinary Behavior: Clinical Applications and Research* 3, 229–239.
- Murgueitio, E., Cuartas, C.A. & Naranjo, J.F. 2008. *Ganadería del Futuro*, Fundación CIPAV, Cali Colombia.
- Murgueitio, E., Calle, Z., Uribe, F., Calle, A., Solorio, B. 2011. Native trees and shrubs for the productive rehabilitation of cattle ranching lands. *Forest Ecology Management* 261, 1654-1663. doi: 10.1016/j.foreco.2010.09.027.
- Murgueitio, E., Giraldo, C. 2009. Sistemas silvopastoriles y control de parasitos. *Revista Carta Fedegán* 115, 60-63.
- Naranjo, J. F., Cuartas C. A., Murgueitio, E., Chará J., Barahona, R. 2012. Balance de gases de efecto invernadero en sistemas silvopastoriles intensivos con *Leucaena leucocephala* en Colombia. *Livestock Research and Rural Development*. 24, Article #150.

- Ocampo, A. Cardozo, A. Tarazona, A. Ceballos, M. & Murgueitio, E. 2011 La investigación participativa en bienestar y comportamiento animal en el trópico de América: oportunidades para nuevo conocimiento aplicada. *Revista Colombiana Ciencias Pecuarias* 24, 332-346.
- Petherick, J.C. 2005 Animal welfare issues associated with extensive livestock production: the northern Australian beef cattle industry. *Applied Animal Behaviour Science* 92, 211-234. doi: 10.1016/j.applanim.2005.05.009
- Santos Silva, J., Tirapicos Nunes, J.L. 2013. Industry and characterization of traditional Mediterranean pig production systems, advantages and constraints towards its development. 8th International Symposium on Mediterranean Pig. Ljubljana, Slovenia.
- Sato, S., Sako, S., Maeda, A. 1991. Social Licking patterns in cattle (*Bos taurus*): influence of environmental and social factors. *Applied Animal Behaviour Science* 32, 3-12.
- Sato, S., Tarumizu, K. Hatae, K. 1993. The influence of social factors on allogrooming in cows. *Applied Animal Behaviour Science* 38, 235-244.
- Tarazona A.M., Ceballos M.C., Naranjo, J.F., Cuartas C.A., Correa G.A., Paranhos da Costa, M.J. (in prep). Welfare of cattle kept in intensive silvopastoral systems.
- Tirapicos Nunes, J. 2007. Livestock management to optimise carcass and meat characteristics in farming systems using natural resources. In: Audiot A., Casabianca F., Monin G. (eds). 5. International Symposium on the Mediterranean Pig, Zaragoza : CIHEAM, pp. 73-82.