

Full Length Research Paper

Characterization of Pico Island (Azores) wood-pastures

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Received 8 October, 2018; Accepted 6 December, 2018

Wood-pastures are gaining importance in various parts of the planet, either for their role in combating desertification, protecting endemic faunas and flora, or their role in animal welfare or nutritional value in all year round grazing systems. On Pico Island and on other islands in the Azores, farmers have been using tree pastures for a long time, especially in the winter, when there is a shortage of grass and the climate is harsh, mainly because of the wind. The studied pasture comprises a mixture of grasses, based on ryegrass (*Lolium perenne*), white clover (*Trifolium repens*), tufted grass (*Holcus lanatus*) and lambs' tongue (*Plantago lanceolata*), on the border of trees, grasses and shrubs. As trees and shrubs, there is incense (*Pittosporum undulatum*), holly (*Ilex perado*), ginger lily (*Hedychium gardnerianum*) and acacia (*Acacia melanoxylon*). The wood pastures, according to the results achieved by us, can be used for animal feed in the livestock production of Pico Island, mainly for meat production. However, further studies should be carried out to assess the impact of the use of wood pastures on the production system, on the mitigation of greenhouse gases produced by animal production and on animal welfare.

Key words: Wood-pastures, unconventional forages, Pico Island, grasses, trees and shrubs.

INTRODUCTION

Wood-pastures are part of the cultural heritage of different parts of the world, playing an important role in providing food for animals and preserving biodiversity (Bergmeier et al., 2010). Grassland with trees can be defined as forests that are systematically grazed (Rackham, 2004). This type of land use involves herding animals, trees, shrubs and grasses. Traditionally managed wood-pastures have high structural diversity, which increases the biodiversity of species that are dependent on various microhabitats, and also bring valuable information to landscape history and ecology (Szabó, 2010; Oldén, 2016).

In the Azores, especially in islands such as Pico, during periods of lack of grass, with two clear periods of scarcity in both summer (particularly August and September) and winter (November through February), especially in the winter, animals are kept in the so-called "invernadores", as a way of protecting them from the adverse conditions, especially the rain and wind (Borba et al., 2015). There, they feed on branches, mainly incense, preserved foods, hay and straw, corn cane and, more recently, silages and some concentrates: corn grain or even commercial concentrate. In these periods of lack of grass, it is normal to use unconventional fodder as sources of fiber, with

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shrubs playing a predominant role. Of the unconventional fodder used in Azorean animal feeding, *Pittosporum undulatum* (incense), *Hedychium gardnerianum* (ginger lily), *Morella faya* (beech) and *Ilex azorica* (holly) can be highlighted (Borba et al., 2015). Some of these species were introduced into the archipelago as ornamental plants (ginger lily) or as fences (incense) but, as a result of their rapid growth, a very important aspect for protection against the wind in the production of orange, they have become invasive plants (Sjögren, 1973).

Pico Island is the second largest island of the Azores archipelago, with an area of 444.89 km² and an economy that is mainly dedicated to agriculture, fisheries and livestock. About 30% of its surface is occupied by forests (SREA, 2016). In this work, the winter pastures of Pico Island (wood-pastures) will be studied, aiming to determine, in a first phase, its composition of trees, shrubs and pastures, and its nutritive value. In a second phase, Pico's wood-pastures and their productivity will be quantified.

The goal is to delimit the current wood-pasture areas on Pico Island and the potential areas that could be occupied by this type of pasture management. In doing so, a portion of this pasture will be characterized in terms of chemical composition and nutritional value of conventional and non-conventional fodder that can be grazed by the animals.

MATERIALS AND METHODS

Delimitation of wood-pastures areas

The areas corresponding to the wood-pastures were delimited based on the observation of the landscape, in a study visit made to the island of Pico, using the method of digitalization above the corresponding aerial photograph, creating a shape file with geo-information in a Geographic Information System where these areas are included using the WGS 1984 UTM Zone 26N georeferencing, with an additional information table that includes the area in square meters and zonal images.

Areas with potential for wood-pastures were delimited through the visualization of landscape units, taking into account the observation of aerial photography and the island's soil chart, which allowed us to better interpret the landscape. The shape file with information from recent lava flows was also used to differentiate forest areas, as well as altimetry to exclude very steep slopes and slopes less than 150 m in areas where holly does not develop.

Forage collection and preparation

The current study was conducted in the Animal Nutrition Laboratory, Department of Agricultural Sciences, University of the Azores, Azores, Portugal. Samples of pasture, grasses, trees and shrubs were collected on the island of Pico, municipality of Madalena, which is found at 345 m altitude. This region is dominated by very fine soils from basaltic pyroclastic materials (bagacina) on lava mantle, litolic soils according to Ricardo et al. (1979). They would fit in the Lhitic Hapludands according to Soil Taxonomy (USDA, 2014).

Samples are harvested manually at three different locations, where the parts of the plantain animals are normally eaten. The

pasture and the trees, grasses and shrubs used as unconventional fodder was analysed. The studied pasture consists of a mixture of grasses, based on ryegrass (*L. perenne*), white clover (*T. repens*), tufted grass (*H. lanatus*) and lambs' tongue (*P. lanceolata*), on the border of trees, grasses and shrubs, the incense (*P. undulatum*), the holly (*I. perado*), the ginger lily (*H. gardnerianum*) and the acacia (*A. melanoxylon*).

Chemical analysis

Dried samples were then ground through a 1-mm screen using a Retsch mill (GmbH, 5657 HAAN, Germany). These ground samples were analysed for dry matter (DM, method 930.15), crude protein (CP, method 954.01) and total ash method (942.05), according to the standard methods of AOAC (1995). Briefly, the dry matter content of the forage was determined by placing samples in a forced air oven at 105°C for 24 h. Total ash was evaluated by igniting samples in a muffle furnace at 500°C for 12 h. Crude protein was determined by standard micro-Kjeldahl method, using digestion equipment (Kjeldatherm System KT 40, Gerhart Laboratory Instruments, Bonn, Germany) and an automated Kjeltac 2300 Auto-analyser apparatus for distillation and titration (Foss Electric, Copenhagen, Denmark). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) was determined according to Goering and Van Soest (1970). *In vitro* digestibility was determined using the Tilley and Terry (1963) method, modified by Alexander and McGowan (1966), and the juice of the rumen was obtained from a slaughterhouse, as described by Borba et al. (2001).

In vitro gas production

In vitro gas production (GP) technique simulates the rumen fermentation process and it has been used to evaluate the potential of feeds to produce greenhouse gas. It is similar to the ruminal process as gas (CO₂ and CH₄) is produced from the carbohydrate fermentation.

Each assay was repeated three times (runs). Blanks were used for each inoculum to measure the fraction of total gas production due to substrate in inocula and these values were subtracted from the total to obtain net GP. All treatments, for each assay, were incubated simultaneously in all runs, as per Menke et al. (1979).

Rumen digesta was collected as described by Borba et al. (2001). The preparation of buffer solutions and rumen inocula was as described by Menke and Steingass (1988).

The initial gas volume was recorded after 4, 8, 12, 24, 48, 72 and 96 hours of incubation.

This gas production represents the kinetic of the rumen apparent GP and is expressed by the McDonald (1981) equation. Gas production profiles were obtained after fitting the data to the exponential equation of Ørskov and McDonald (1979):

$$p = a + b(1 - \exp^{-ct})$$

Where, p represents the gas production at time t ; the values of a , b and c represent constant values in the exponential equation; $a+b$ the total potential gas production (ml/g DM), and c the rate constant

RESULTS AND DISCUSSION

The area of wood-pastures currently used on Pico Island is 752.87 ha, as can be seen in Figure 1. In the past, this area was much more extensive, having decreased

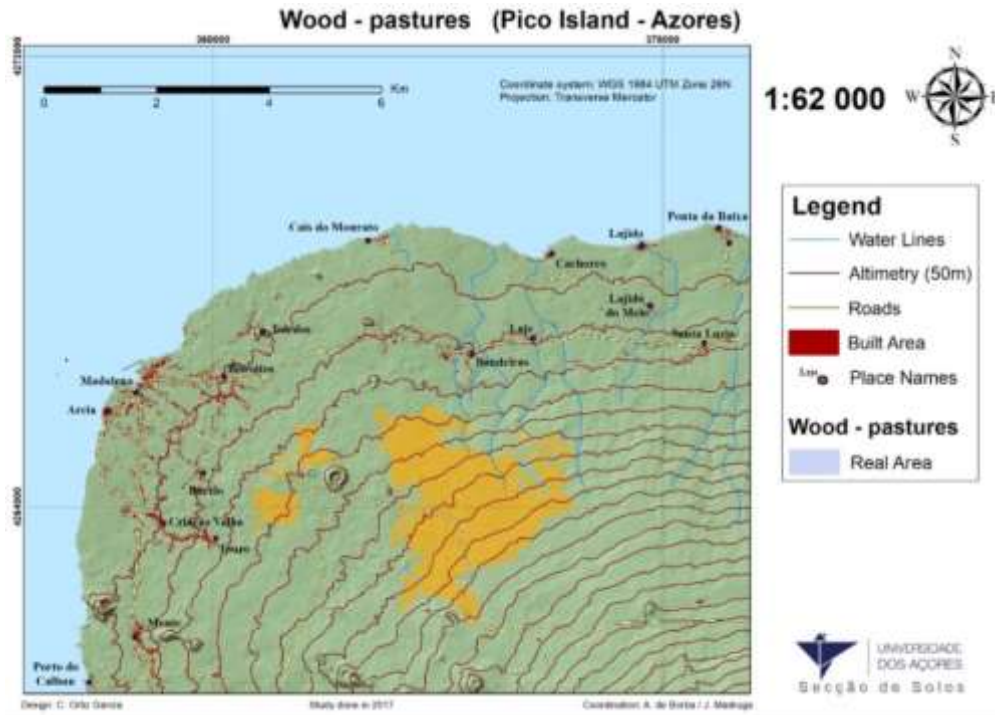


Figure 1. Current wood-pasture areas on Pico Island.



Figure 2. Potential wood-pasture areas on Pico Island.

with the intensification of the production system.

In the delineation of the potential areas for the installation of wood-pastures (Figure 2), the soil,

susceptible to support pasture and the normal growth altitude of holly were taken into account, since the ginger lily and incense grow in almost all environments. For this

Table 1. Chemical composition and nutritive value of wood-pastures forages.

Forage	DM (%)	100 g DM						DMD (%)
		CP	NDF	ADF	ADL	EE	Ash	
Pasture	10.73	22.34	51.53	30.96	4.72	5.04	10.42	64.20
Holly	30.11	8.76	50.12	44.72	21.88	6.46	5.48	55.36
Ginger lily	16.60	6.73	66.04	35.51	5.53	4.06	8.94	42.38
Incense	32.60	9.60	30.97	25.76	9.99	4.56	6.51	66.73
Acacia	44.24	15.04	64.84	53.54	31.18	3.68	4.75	31.63

DM, Dry Matter; CP, Crude Protein; NDF, Neutral Detergent Fiber; ADF, Acid Detergent Fiber; ADL, Acid Detergent Lignin; EE, Extract Ether; DMD, *In vitro* Dry Matter Digestibility.

Table 2. Equation terms for gas production, including residual standard deviations (rsd).

Parameter	a	b	c	Lag time (h)	RSD
Pasture	-5.15	53.83	0.0472	2.1	1.23
Holly	-0.96	33.77	0.0441	0.7	0.71
Ginger lily	3.46	57.04	0.0397	0	1.24
Incense	-6.63	33.33	0.0647	3.4	1.29
Acacia	1.96	13.16	0.0382	0	0.31

reason, these areas are located at an altitude varying between 150 and 550 m, on average, although it falls occasionally down to 120 m (in the case of São Mateus), or up to 700 m (in the case of Santa Luzia).

Form the results presented in Table 1, the high crude protein content of the pasture (22.34% DM) and the high lignin content of the acacia (31.18% DM) are of note, resulting in a low digestibility of DM (31.63%). Lignin, is a molecule in biochemical terms of great complexity and almost indigestible in nutritional terms (Jung et al., 1982). Pasture presents the lowest DM value (10.73%), while acacia wood shows the highest (44.24%). Holly also exhibits a high ADL value (21.88%DM), while Ginger lily has the lowest CP value (6.73%), even lower than the 7% suggested by Lazzarini et al. (2009) as the minimum limit for normal microbial activity in the rumen. Incense has the lowest NDF value (30.97% DM), mostly made up of cellulose, which translates into the high value of DMD (66.73%).

Analysing the results obtained in Table 1, it can be noted that the holly presents similar results to the ones found by Borba et al. (2015a) for Terceira Island. Presenting a slightly higher value in crude protein (CP) and lower in NDF, those authors report a CP value of 7.48% DM and NDF 52.02% DM.

The incense presents appreciably better values than those found by Moselhy et al. (2014) for Terceira island, where they refer to CP values of 6.11% DM and 43.84% DM of NDF. The values for dry matter are lower than those reported by Moselhy et al. (2015), which refers to a value of 15.64%, a higher value in crude protein, in NDF, ADF and ADL, those authors refer to 18.66, 49.41, 27.28

and 2.68% of DM, respectively.

The contents are lower than those reported by Moselhy et al. (2015) for the ginger lily, (6.73 versus 8.05% of DM), NDF (66.04 versus 75.69% of DM), ADF (35.51 versus 48.69% of DM) and ADL (5.53 versus 8.96% of DM).

Acacia has values very similar to those reported by Singh et al. (1997), although the protein value is significantly lower than that presented by those authors (15.04 versus 20.70% of DM). In relation to Acacia, Burner et al. (2008) report the need for toxicity studies of this species, although there is no documentation to support the negative effect of this species on ruminant feed.

Regarding the digestibility of DM, it can be seen that both the incense and the holly, have a good nutritive value, being acacia the forage that presents lower values of digestibility. Other authors, namely Dynes and Schlink (2002) and Gebeyew et al. (2015) report digestibility values of acacia leaves higher than those current finding, so these authors state that acacia is a potential feed supplement for livestock Production.

Wood-pastures *in vitro* gas production results (Table 2) show that the initial time of fermentation (Lag Time) varies greatly from forage to forage, ranging from 0 hours to 3.4 hours. This variation is in line with previous findings (Tuah et al., 1996). It was observed that the acacia and the ginger lily have a Lag Time of 0 hours, while the pasture presents a Lag Time of 2.1 h and the incense of 3.4 hours. According to the gas production curves (Figure 3), acacia and incense are the least gas-producing forage, with ginger lily and pasture being the major

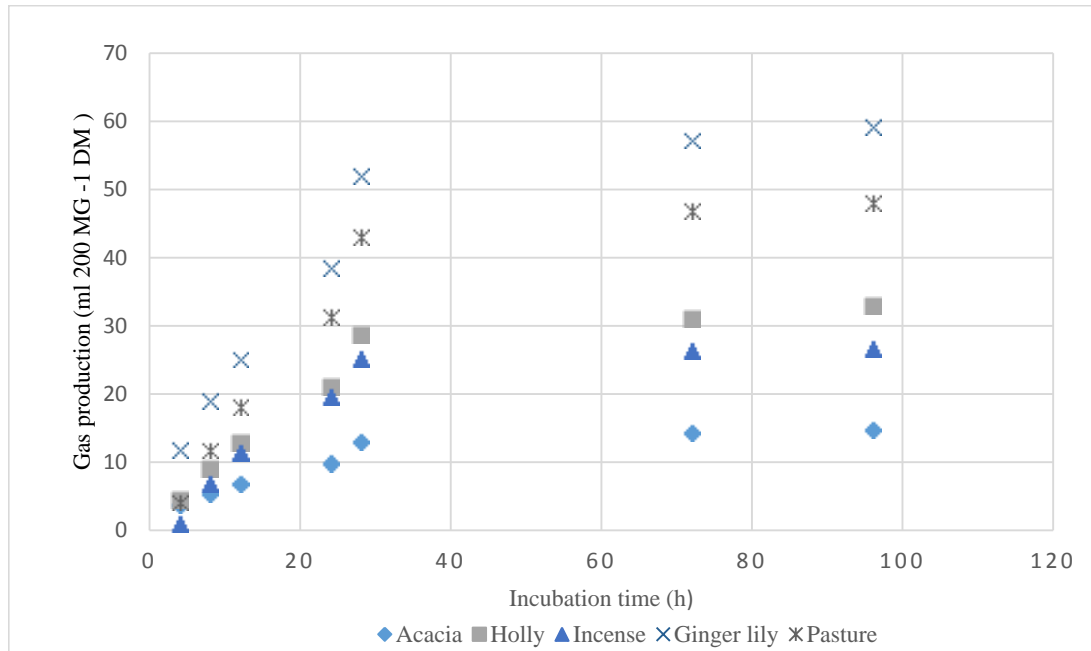


Figure 3. Pattern of *in vitro* gas production (fitted with exponential model) on incubation of wood pastures in buffered rumen fluid.

producers, indicating the potential inhibition of acacia gas production and of incense, already confirmed for incense by Moselhy et al. (2014), who verified a little inhibitory effect on total gas by ginger lily.

The archipelago of the Azores has a Usable Agricultural Area (UUA) of 120 400 hectares, with 16% of the UUA on the island of Pico and 19.5% of the agricultural holdings in the archipelago. Dairy cattle have strategic importance for the archipelago, especially in the islands of S. Miguel, Terceira and S. Jorge, on both the agro-industrial and territorial levels (DGIP, 2015).

The island of Pico is an island with a strong vocation for the production of beef cattle. According to the SREA (2016), beef cattle slaughtered on the island of Pico increased by 26.6% from the year 2014 to the year 2015. This type of animal production tends to increase on this island, especially the PGI meat (Protected Geographical Indication). It is on this island that about 40% of PGI Azores beef producers are located.

Wood-pastures are characteristic of traditional extensive grazing systems in forested areas (Oldén et al., 2016). The system of wood-pastures exploitation is less intensive than the conventional pastures. Its management must allow, on the one hand, for the regeneration of the trees and shrubs and, on the other hand, it must prevent the invasion by the arboreal cover. This finding is verified throughout Europe, as noted by Plieninger et al. (2015), and is the main reason for the decrease of these pasture areas in the Azores, which has significantly intensified its production system in the last 40 years.

Trees and shrubs on pasture have many agronomic functions. They provide additional forage for livestock, with complementary nutrition and fiber, and play an essential role in overcoming the lack of grass in summer and winter. Trees provide shelter for livestock from sun, rain and wind, and deposit nutrients in soil, when they lose their leaves.

Carmona et al. (2013) concluded that not only the number of animals grazing on land, but also the time of grazing, determine the condition and density of the holm oaks trees.

With very few exceptions, wood-pastures are not recognized in European Union nature conservation policies and are not protected as distinct land cover types with a special history of management, ecological and cultural value (Hartel et al., 2013). The important role they play in animal welfare, especially in the winter, when it is cold, windy and there is heavy rain, should also be highlighted.

Van Uytvanck et al. (2008) reported that due to its great value for conservation wood-pastures restoration should be encouraged, bearing in mind that the initial regeneration of the tree is an essential component of recovery, but may be hampered by grazing. In the Azores, due to the type of trees used, of great growth and burst capacity, some of them being weeds that need to be controlled, the problem of overgrazing does not arise.

The wood pastures can be used for animal feed in the livestock production of the island of Pico, mainly in the production of meat. However, further studies should be carried out to assess the impact of the use of wood

pastures on the production system, on the mitigation of greenhouse gases produced by animal production and on animal welfare.

Conclusions

It is concluded that wood-pastures are a potential system for animal production in the Island of Pico, especially for the production of beef cattle. It makes way for a sustainable animal production, with respect to the environment and animal welfare, ideal for an organic production system as recommended by the European Union, in the CAP 2014-2020, and for the IGP (Protected Geographical Indication) system for the production of “Carne dos Açores” (Meat from the Azores).

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors appreciate the financial support from FEDER funds via the Operational Programme Competitiveness Factors – COMPETE and the National Funds via the FCT – Foundation for Science and Technology of the Ministry for Science, Technology and Higher Education of Portugal within the scope of project “UID/CVT/00153/2013.

REFERENCES

- Alexander RH, McGowan M (1966). The routine determination of *in vitro* digestibility of organic matter in forages. An investigation of the problems associated with continuous large-scale operation. *Journal of the British Grassland Society* 21(2):140-147.
- Association of Official Analytical Chemists (AOAC) (1995). *Official Methods of Analysis*. 16th ed. Association of Official Analytical Chemists, Virginia, USA.
- Bergmeier E, Petermann J, Schroder E (2010). Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation. *Biodiversity and Conservation* 19(11):2995-3014.
- Borba AES, Correia PJA, Fernandes JMM, Borba AFRS (2001). Comparison of three sources of inocula for predicting apparent digestibility of ruminant feedstuffs. *Animal Research* 50(4):265-274.
- Borba AES, Dias EMF, Maduro Dias CSA, Mendes CM (2015a). Valor nutritivo de plantas presentes em turfeiras pastoreadas dos Açores. In: *Wetland Processes and Dynamics: An approach to Peatland Restoration, Workshop II*. Angra do Heroísmo, 20-21 de novembro de 2015.
- Borba JPR, Maduro Dias CSAM, Rosa HJD, Vouzela CFM, Rego OA, Borba AES (2015). Nutritional valorization of ginger lily forage (*Hedychium gardnerianum*, Sheppard ex Ker-Gawl) for animal feeding: treatment with urea. *African Journal of Agricultural Research* 10(50):4606-4615.
- Burner DM, Carrier DJ, Belesky DP, Pote DH, Ares A, Clausen EC (2008). Yield components and nutritive value of *Robinia pseudoacacia* and *Albizia julibrissin* in Arkansas, USA. *Agroforestry Systems* 83(1):51-62.
- Carmona CP, Azcárate FM, Osteros-Rozas E, Gonzáles JA, Peco B (2013). Assessing the effects of seasonal grazing on holm oak regeneration: Implications for the conservation of Mediterranean dehesas. *Biological Conservation* 159(3):240-247.
- Directorate-General for Internal Policies (DGIP) (2015). *The Agriculture of the Azores Islands. Study*. Author: Albert Massot. Editorial Assistance: Catherine Morvan. Policy Department B: Structural and Cohesion Policies. Agricultural and Rural Development. European Union. BE – 1047 Brussels.
- Dynes RA, Schlink A (2002). Livestock potential of Australian species of Acacia. *Conservation Science Western Australia* 4(3):117-124.
- Gebeyew DM, Beriso K, Mohamed A, Silassie G, Melaku S, Worku A (2015). Review on the nutritive value of some selected acacia species for livestock production in dryland areas. *Journal of Advances in Dairy Research* 3(2):139.
- Goering HK, Van Soest PJ (1970). Forage fiber analyses. *Agricultural Handbook* nº379, Washington, DC, USA.
- Hartel T, Dorresteijn I, Klein C, Máthé O, Moga CI, Öllerer K, Roellig M, von Wehrden H., Fischer J (2013). Wood-pastures in a traditional rural region of eastern Europe: Characteristics, management and status. *Biological Conservation* 166(3):267-275.
- Jung GA, Wilson LL, Le Van PJ, Kocher RE, Tood RF (1983). Herbage and beef production from ryegrass-alfalfa and orchardgrass –alfalfa pastures. *Agronomic Journal* 74(6):937-942.
- Lazzarini I, Detmann E, Sampaio CB, Paulino MF, Valadares Filho SC, Souza MA, Oliveira FA (2009). Dinâmicas de trânsito e degradação da fibra em detergente neutro em bovinos alimentados com forragem tropical de baixa qualidade e compostos nitrogenados. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia* 61(3):635-647.
- McDonald I (1981). A revised model for the estimation of protein degradability in the rumen. *Journal of Agricultural Science Cambridge* 96(2):251-252.
- Menke KH, Raab L, Salewski A, Steingass H, Fritz D, Schneider W (1979). The estimation of the digestibility and metabolizable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor *in vitro*. *Journal of Agricultural Science, Cambridge* 92(1):217-222.
- Menke KH, Steingass H (1988). Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research and Development* 28(17):7-55.
- Mosely MA, Borba JP, Borba AEB (2015). Improving the nutritive value, *in vitro* digestibility and aerobic stability of *Hedychium gardnerianum* silage through application of additives at ensiling time. *Animal Feed Science and Technology* 206(2015):8-18.
- Mosely MA, Nunes HP, Borba AEB (2014). Effect of replacement of ordinary ruminant feed with *Hedychium gardnerianum* or *Pittosporum undulatum* on *in vitro* rumen fermentation characteristics. *International Journal of Advanced Research* 2(10):91-104.
- Oldén A (2016). Plant biodiversity in boreal wood-pastures: Impacts of grazing and abandonment. *Academic Dissertation*. Jyväskylä Studies in Biological and Environmental Science 318:1-46.
- Oldén A, Ratikainen KJ, Tervonen K, Hlame P (2016). Grazing and soil pH are biodiversity drivers of vascular plants and bryophytes in boreal wood pastures. *Agriculture Ecosystems and Environment* 222(4):171-184.
- Ørskov ER, McDonald P (1979) The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science Cambridge* 92(2):499-503.
- Plieninger T, Hartel T, Martín-López B, Beaufoy G, Bergmeier E, Kirby K, Montero MJ, Moreno G, Oteros-Rozas E, Van Uytvanck J (2015). Wood-pastures of Europe: Geographic coverage, social-ecological values, conservation management, and policy implications. *Biological Conservation* 190(10):70-79. DOI: 10.1016/j.biocon.2015.05.014.
- Rackham O (2004). *The history of countryside, the classic history of Britain's landscape flora and fauna*. Phoenix Press, London, UK.
- Ricardo RP, Madeira MAV, Medina JMB (1979). Enquadramento taxonómico dos principais tipos de solos que se admite ocorrerem no Arquipélago dos Açores. *Anais do Instituto Superior de Agronomia* 38:167-180.
- Singh P, Chaudhary LC, Verma AK, Pathak NN (1997). Nutritive value of *Robinia pseudoacacia* leaves in growing soviet chinchilla

- rabbits. *World Rabbit Science* 5(4):135-137.
- Sjögren E (1973). Recent changes in the vascular flore and vegetation of the Azores islands. *separata de Memórias da Sociedade Broteriana* 22:479.
- Serviço Regional de Estatística dos Açores (SREA) (2016). *Estatísticas da Agricultura. Janeiro a Dezembro de 2015. Angra do Heroísmo, Açores Portugal.*
- Szabó P (2010). Ancient woodland boundaries in Europe. *Journal of Historical Geography* 36:205-214.
- Tilley JMA Terry RA (1963). A two-stage technique for the *in vitro* digestion of forage crops. *Journal of the British Grassland Society* 18(2)104-111.
- Tuah AK, Okai DB, Ørskov ER, Kyle D, Wshand GJFD, Obese FY Karikari PK (1996). *In sacco* dry matter degradability and *in vitro* gas production characteristics of some Ghanaian feeds. *Livestock Research. Rural Development* 8(1) article 3, Retrieved June 26, 2018, from <http://www.lrrd.org/lrrd8/1/tuah.htm>.
- United States Department of Agriculture (USDA) (2014). *Keys to Soil Taxonomy. Twelfth Edition.*
- Van Uytvanck J, Maes D, Vandenhoute D, Hoffman M (2008). Restoration of wood pasture on former agricultural land: the importance of safe sites and time gaps before grazing for tree seedlings. *Biological Conservation* 141(1):78-88.