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A comparative study of production performance and animal health practices in organic and conventional dairy systems

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Abstract Health and production management strategies influence environmental impacts of dairies. The objective of this paper was to measure risk factors on health and production parameters on six organic and conventional bovine, caprine, and ovine dairy herds in southeastern Brazil over six consecutive years (2006–2011). The organic operations had lower milk production per animal ($P \leq 0.05$), lower calf mortality ($P \leq 0.05$), less incidence of mastitis ($P \leq 0.05$), fewer rates of spontaneous abortions ($P \leq 0.05$), and reduced ectoparasite loads ($P \leq 0.05$) compared to conventional herds and flocks. Organic herds, however, had greater prevalence of internal parasitism ($P \leq 0.05$) than conventional herds. In all management systems, calves, kids, and lambs had greater oocyte counts than adults. However, calves in the organic group showed lower prevalence of coccidiosis. In addition, animals in the organic system exhibited lower parasitic resistance to anthelmintics. Herd genetic potential, nutritive value of forage, feed intake, and pasture parasite loads, however, may have influenced productive and health parameters. Thus, although conventional herds showed greater milk production and less disease prevalence, future research might quantify the potential implications of these unreported factors.

Keywords Brazil · Cattle · Goat · Milk production · Sheep · Sustainability

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Introduction

In warm tropical climates, dairy production systems are characterized by low animal performance compared to cooler climates, not only because of the direct effects of climate, but also due to poor forage nutritive value, unavailable concentrate feeds, and greater incidence of disease and parasites (Payne 1990). Disease caused by internal and external parasites is arguably one of the most important health constraints affecting productivity in ruminants kept in tropical organic and conventional systems (Pruett et al. 2008; Silva et al. 2011; Chartier and Paraud 2012). This is of particular importance for many countries like Brazil where cattle, goats, and sheep play a vital role in the agricultural economies. Today, Brazil has approximately 200 million head of cattle (in 2.37 million km^2), of which 26 million are dairy cows, making it the fifth largest milk producer in the world (30 billion liters). Brazil also has 22 million small ruminants comprised of 8 million goats and 14 million sheep (IBGE 2012).

Organic and other non-intensive animal production systems are of growing importance in several countries worldwide (Thamsborg 2001). In 2005, organic milk production in Brazil was estimated at 0.01 % (2.4 million liters) of the total milk production. Although Brazilian organic milk is still slight, an increase of 187 % was observed between 2005 and 2010 (Soares et al. 2012).

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Livestock production systems differ in their environmental impacts. The principles and standards employed in organic production constitute a radical break with the productivist paradigm, and are poorly documented in most livestock species (Cabaret 2003). At present, although anthelmintics are not always used in conventional systems, one of the differences between organic and conventional production is that the prophylactic use of anthelmintics is prohibited in organic herds (Anon 2002). Thus, the purpose of the paper is to compare health and production risk factors between organic and conventional dairies of three ruminant species in Brazil.

Materials and methods

Data collection

This study was conducted from January 2006 to December 2011 as a collaborative effort among Embrapa Agrobiologia, Pesagro-Rio and Universidade Federal Rural of Rio de Janeiro. Data were collected from six dairy herds in southeastern Brazil, in the municipality of Seropédica, Rio de Janeiro, located at latitude 45′ S 22nd, 43rd 41′ W longitude GRW, and altitude 33 m.

As with most of the small farms in Brazil, all farms studied have no database relating to occurrence of diseases, use of medications, genetics, and nutrition quality. Thus, we chose not to conduct an inquiry in which such information was collected.

Ruminant species evaluated

Data on milk production and health were available from 448 animals in three ruminant species (cattle, goats, and sheep). The first experimental group consisted of 78 cattle (54 cows and 24 calves) kept in an organic production system and 140 cattle (80 cows and 40 calves) under conventional production system. The second experimental group consisted of 50 goats (30 goats and 20 kids) kept in an organic production system and 60 goats (40 goat and 20 kids) under conventional production systems. The third experimental group consisted of 40 sheep (20 ewes and 20 lambs) kept in an organic production system and 80 sheep (50 ewes and 30 lambs) under conventional production.

Cattle trial

The trial compared two dairy herds for four consecutive years (2008–2011). Data from a conventional herd was obtained at the Embrapa Agrobiologia and from an organic herd at the Pesagro-Rio. The organic production system consisted of 54 *Girolando* cows (5/8 Holstein × 3/8 Gyr) aged 3 to 9 years. A total of 24 calves (5/8 Holstein × 3/8 Gyr) born during the trial were included in the analysis. The cows were kept in 11 paddocks measuring approximately 7,000 m^2 total. As roughage fodder, the organic farm used Tanzania grass (*Panicum maximum* cv. Tanzania) in association with the legume calopo (*Calopogonium muconoides*) during the rainy season while during the dry season (April to September), the cows received elephant grass (*Pennisetum purpureum* Schum cv. Cameroon) plus siratro (*Macroptilium atropurpureum* (DC) Urb.) and sugarcane (*Saccharum* spp.) as roughage supplement. Water and mineral salt was available ad libitum at all times. A 7-day rotational grazing system (1 day grazing, 6 days rest) stocked at 2.0 ha/AU was used.

According to the recommendations for organic management under Normative Instruction (NI) 46 from the Ministério da Agricultura Pecuária e Abastecimento (MAPA), calves remained with the cows during milking until 3 months of age. From birth to 2 months, calves were kept in coastcross grass (*Cynodon dactylon* (L.) Pers., Coastcross) paddocks measuring 60 m^2 at rotational system (5 days) and in stalls at night. During the third month of age, calves were kept on African Star pasture (*Cynodon nlemfuensis*, Vanderyst) in association with legumes *Arachis pintoi* Krapov. & W.C. Greg., *Desmodium ovalifolium* (Prain) Wall. ex Merr. and *Stylosanthes guianensis* (Aubl.) Sw. divided into four paddocks of 1,175 m^2 in 8-day grazing rotations (7 days rest between grazing). During the dry season, calves were fed the legume *Gliricidia sepium* (Jacq.) Walp. and sugarcane in association with another legume, pigeon pea (*Cajanus cajan* (L.) Millsp.), as roughage supplement. The animals received water and mineral salt ad libitum.

The organic system was based on native pasture paddocks where no cattle had previously entered, indicating the absence of pre-existing parasitic infestations in pasture area. Furthermore, the cattle introduced into the herd in 2005 showed low levels of parasitic burdens, and 1 month prior to the commencement of the trial, mean fecal egg and oocyst count was 210 and 50, respectively. The animals were not previously dewormed due the prohibition on the use of anthelmintic in Organic Brazilian Certification.

In the conventional production system, the dairy herd consisted of 80 crossbred cows (½ Holstein × ½ Gyr) aged from 3 to 8 years. The cows were kept on pasture (*Brachiaria decumbens* (Stapf)) paddocks measuring approximately 7,000 m^2 grazed in 7-day rotations (6 days rest). After calving, lactating cows were fed 3.0 kg of 18 % CP concentrate. From birth to 4 months, calves in the conventional system remained in individual stalls and were fed milk twice a day plus concentrate and water ad libitum. In the morning, after receiving milk from a bottle, calves were allowed to graze *Brachiaria humidicula* (Rendle) Schweick pasture. From 5 to 12 months of age, calves had access to *P. maximum* Jacq. Pasture while from 1 to2 years of age, calves were kept under an agropastoral system. Once heifers reached 2 years of age, they were introduced into the rest of the herd and artificially inseminated.

All animals under the conventional system were dewormed trimonthly using levamisole phosphate (10 mg/kg, Ripercol® L 150 F, Fort Dodge, Brazil). One month prior to the commencement of the experiment, mean fecal egg and oocyst count was 200 and 50/g feces, respectively. Before the trial period, degraded pastures were reseeded, followed by 12 months rest period. Although not directly measured, we believed that the initial level of parasitic infestation in paddocks was low.

Goat trial

The study was conducted in two dairy goat flocks for four consecutive years (2006–2009). Two experimental groups (organic and conventional) were compared. Data from conventional and organic herds was obtained at the Universidade Federal Rural of Rio de Janeiro. A total of 110 Saanen goats were evaluated. All goats were milked twice a day during lactation. The organic flock consisted of 30 females and 20 kids. In the organic farm, goats were kept in six 1.5 ha *Brachiaria humidicola* paddocks grazed rotationally with 30 days rest between grazing, and stocked at 2.2 ha/AU. The conventional flock consisted of 40 nannies and 20 kids on *B. decumbens* pasture stocked at 4.4 ha/AU. In the conventional farm, goats were fed 1 kg concentrate/day with 22 % CP. In both systems, during the dry season, goats received Cameroon elephant grass and sugarcane as roughage supplement.

The animals under the conventional system were dewormed monthly using levamisole phosphate (10 mg/kg, Ripercol® L 150 F). One month prior to the trial, mean fecal egg and oocyst count per gram of feces was 400 and 200, respectively.

In the organic system, the animals were purchased from a local goat farm 6 months before these experiments began, and their gastrointestinal nematode egg and oocyst counts were 440 and 230/g feces, respectively. Native range was used to form the paddocks for the flock the year prior to the trial.

Sheep trial

The trial was conducted in two flocks for three consecutive years (2008–2010). A total of 120 sheep were studied. Two experimental groups (organic and conventional) were evaluated simultaneously. Data from conventional and organic flocks were obtained at the Universidade Federal Rural of Rio de Janeiro. In the organic system, from a total of 240 animals, 40 Santa Ines crossbred sheep were included in the study. The sheep were rotationally grazed in *B. humidicola* pastures (28 days rest) stocked at 1.1 ha/AU. During the dry season, the sheep received Cameroon elephant grass as roughage supplement and concentrate with 19 % CP per animal.

In the conventional flock, from a total of 400 animals, 80 Santa Ines crossbred sheep were evaluated. During the morning, the sheep were rotationally grazed on Tifton 85 (*Cynodon* spp.) pasture (28 days rest) stocked at 2.2 ha/AU. At night, animals were housed in stalls with a space allowance of 3.0 m^2/sheep and received Cameroon elephant grass and 19 % CP concentrate per head. All animals were dewormed using levamisole phosphate (10 mg/kg, Ripercol® L 150 F) monthly.

The animals in both systems were evaluated starting from their introduction into the herd. The paddocks were established on land previously used for row crops. Before the experiment, nematode and oocyst excret per gram of feces on the organic herd were 300 and 90, respectively, while in conventional animals these values were 320 and 140, respectively.

Health parameters analyzed

The following health variables were investigated: number of gastrointestinal nematode eggs per gram of feces, numbers of oocytes per gram of feces, abortions, clinical mastitis, tick counts, louse counts, lameness, anthelmintic use, and parasitic resistance. The tick counts, louse counts, and lameness variables were categorized as: absent, low (5 %), medium (>5 and <30 %), and high (>30 %). The anthelmintic use variable was categorized as: occasional (10 %), low (>10 and <20 %), medium (>20 and >60 %), and high (>60 %).

Fecal egg counts

Fecal samples were collected fortnightly from all animals during the study. The numbers of gastrointestinal nematode eggs per gram of feces and oocysts of protozoa were counted using the McMaster technique, as described by Gordon and Whitlock (Gordon and Whitlock 1939).

Abortions

Abortion incidence rate was calculated as the number of abortions divided by the number of pregnancies.

Clinical mastitis

Clinical mastitis was defined as the animal having a swollen or hard udder or noticeable clots or strings in its milk. Recurrent episodes of disease were counted as the same case if the recurrence occurred within 2 weeks of initial onset. Animals with multiple infected quarters were counted as the same case. The rate for each herd was calculated as the number of clinical mastitis cases per 100 animal-years at risk.

Tick and louse counts

To count ticks, animals were restrained individually and all the fully or partially engorged females of *Rhipicephalus microplus* and *Amblyomma cajennense* measuring between 4.5 and 8.0 mm on the right side were counted as described by Wharton et al. (1970). The result from each count was multiplied by two to obtain the monthly average for each animal.

Lameness

Prevalence of lameness and risk indicators for dermatitis digitalis during pasturing and housing of dairy herds were evaluated during the study. Herd prevalence of hoof lesions and clinical lameness were calculated as the number of affected animals divided by the number examined.

Anthelmintic use

Anthelmintic use was calculated as the number of dewormed animals divided by the number of animals in the herd.

Parasite resistance

An egg hatch assay (EHA) for helminths was used to evaluate the in vitro anthelmintic activity of the drugs according to the World Association for the Advancement of Veterinary Parasitology (WAAVP) guidelines (Coles et al. 1992).

Production parameters analyzed

The following production variables were investigated: milk yield, interval between births, average daily gain (ADG) in young, mortality rate at 6 months, lactation duration, percentage of lactating animals in herd or flock, and stocking area.

Labor interval

Labor interval was calculated as the sum of interval between births divided by the number of animals in the herd.

Average daily gain in the young

Average daily gain in animals up to 6 months was calculated as the body weight gain divided by the number of days evaluated.

Young mortality

Mortality rate of the young was estimated as the number of animals that died after birth and before weaning.

Lactation period and lactating animals

Lactation duration of individual animals was recorded every day during the experiment. Lactating animal rate was obtained as the number of lactating animals divided by the number of animals at reproductive age.

Statistical analyses

An observational study of production performance and animal health was conducted in three ruminant species (cattle, goats, and sheep) from two dairy properties. Thus, two experimental groups of each species were formed, the first from an organic production system and the second from a conventional system. The total number of animals observed in organic groups was lower than the conventional groups due smaller, non-uniform herds. The experimental unit consisted of the individual animals under observation. Animals were randomly selected from within the dairy herd or flock in each farm. Discriminant analysis, a statistical technique used to distinguish between two or more groups of cases, was used to determine qualitative variables (no=0; yes=1).

For statistical analyses, the eggs per gram data were initially transformed into $\log_{10}(x+1)$ in order to normalize them. For quantitative assessment of different parameters, analysis of variance was used, along with the Tukey's test at 5 % significance. The operating procedures were performed using the statistical software R Foundation for Statistical Computing, version 2.12.2 (2011). Significance for all results was considered at $P \leq 0.05$.

Results

Health parameters

The incidence of mastitis and abortions in cows and goats were greater in conventional systems than in the organic systems (Tables 1 and 2). There were also differences in fecal egg/oocyst counts between the two livestock systems and among ruminant species. In adult dairy cows and calves, fecal egg counts were substantially greater in the organic herd compared to conventional herd. The same was observed in kids in 2006 and sheep and lambs in all years. Adult goats on conventional farm had greater fecal egg counts in 2006 and 2009 than those on the organic farm. In 2009, kids also showed a greater fecal egg count in the conventional system. In all management systems, calves, kids, and lambs had greater oocyst counts than adults. By contrast, all calves in the organic system showed low oocyst counts.

Tick counts were greater in the conventional cattle herds and goats flocks compared to organic systems; the exception

Table 1 Production and health parameters in dairy cattle under organic and conventional production systems

Variable	2008			2009			2010			2011		
	Org.	Con.	*P* values*	Org.	Con.	*P* values	Org.	Con.	*P values*	Org.	Con.	*P* values
Productive parameters/animal												
Lactating cows (%)	77.7	81.2	0.0861	88.8	77.5	0.0655	81.4	85	0.0675	85.1	87.5	0.1210
Milk yield (kg/day)	7.0	9.0	0.0867	8.5	12.0	0.0469	6.5	10.0	0.0268	5.8	11.0	0.0253
Labor interval (months)	12	12	0.9801	12.5	12	0.1209	12	12	0.9318	12	12	0.9805
Average daily gain (g/day)	176	208	0.0731	182	218	0.0045	155	242	0.0131	169	212	0.0821
Lactation period (days)	281	280	0.9890	279	290	0.7651	288	297	0.8722	283	289	0.9081
Calve mortality (%)	3.7	2.5	0.0768	1.8	3.7	0.0431	1.8	0	0.0065	0	1.25	0.0242
Health parameters/animal												
Fecal egg counts/cow	250	100	0.0326	300	200	0.0621	400	250	0.0568	280	200	0.0753
Fecal egg counts/calve	600	300	0.0432	500	250	0.0312	700	200	0.0091	800	200	0.0041
Tick count	8	21	0.0034	11	23	0.0323	17	21	0.0564	15	22	0.0655
Louse count	0	5	0.0022	2	0	0.0451	0	0	1.0000	0	0	1.0000
Lameness (nº cattle)	0	1	0.0987	0	0	1.0000	0	0	1.0000	2	1	0.0980
Abortions (%)	3.7	2.5	0.0777	1.8	5	0.0323	0	5	0.0121	0	2.5	0.0452
Clinical mastitis (%)	3.7	5	0.0672	3.7	7.5	0.0361	7.4	10	0.0381	5.5	7.5	0.0532
Antiparasitic use (%)	0	100	2.897^{e-8}	0	100	2.897^{e-8}	0	100	2.897^{e-8}	0	100	2.897^{e-8}

Org. organic, *Con.* conventional

* $P \leq 0.05$, probability of significant effects due to production system

was the last year for both species (Tables 1 and 2). In contrast, sheep in the organic herd had greater tick and louse counts compared to the animals in the conventional system (Table 3).

In the first year of the study, organic practices resulted in less louse counts for dairy cattle and goats. However, in the second year, the opposite was observed. Anthelmintic use was greater

Table 2 Productive and health parameters in dairy goats under organic and conventional production systems

Variable	2006			2007			2008			2009		
	Org.	Con.	*P* values*	Org.	Con.	*P* values	Org.	Con.	*P* values	Org.	Con.	*P* values
Productive parameters												
Lactating goats (% of flock)	68	70	0.0786	80	87	0.0864	92	90	0.1209	80	87	0.0453
Milk yield/nanny (kg/day)	2.0	2.4	0.0644	2.0	3.0	0.0589	1.4	2.6	0.0436	1.6	2.6	0.0311
Labor interval/nanny (months)	12	10	0.0762	11.5	12	0.8959	12	11	0.2765	11	11	0.9876
Average daily gain/kid (g/day)	90	180	0.0014	108	118	0.0089	95	112	0.0833	97	112	0.0112
Lactation period/nanny (days)	270	240	0.0453	265	240	0.0564	270	240	0.0652	265	240	0.0563
Kid mortality (%)	8	5	0.0530	4	2.5	0.0453	0	5	0.0012	0	5	0.0034
Health parameters												
Fecal egg counts/nanny	395	1,100	0.0213	700	600	0.0831	275	900	0.0611	240	660	0.0361
Fecal egg count/kid	9,400	1,500	0.0035	880	180	0.0632	700	2,000	0.0771	775	1,300	0.0212
Tick count/animal	0	10	0.0231	0	5	0.0451	0	10	0.0229	0	0	1.0000
Louse count/animal	0	5	0.0142	2	0	0.0344	0	0	1.0000	0	0	1.0000
Lameness (nº goats/flock)	0	2	0.0453	0	0	1.0000	2	0	0.0432	2	0	0.0430
Abortions (% of pregnancies)	0	5	0.0463	4	2.5	0.0785	0	5	0.0463	4	7.5	0.0453
Clinical mastitis (% of flock)	4	5	0.0644	8	7.5	0.0879	4	5	0.0436	8	7.5	0.0311
Antiparasitic use (% of flock)	0	25	2.453^{e-6}	4	50	2.182^{e-4}	0	75	1.032^{e-6}	0	100	3.098^{e-11}

Org. organic, *Con.* conventional

* $P \leq 0.05$, probability of significant effects due to production system

Table 3 Production and health parameters in dairy sheep under organic and conventional production systems

Variable	2008			2009			2010		
	Org.	Con.	*P* values*	Org.	Con.	*P* values	Org.	Con.	*P* values
Productive parameters									
Lactating ewes (% of flock)	80	70	0.0561	85	87	0.8703	90	90	0.9811
Milk yield (kg/day/ewe)	1.1	1.6	0.0451	1.3	2.0	0.0455	1.2	1.5	0.0778
Labor interval (months/ewe)	12	11	0.2310	12	12	0.9390	12	11	0.2310
Average daily gain (g/day/lamb)	134	192	0.0501	108	216	0.0209	128	218	0.0476
Lactation period (days/lactation)	220	230	0.0723	235	240	0.3425	220	245	0.0890
Lamb mortality (% of flock)	5	4	0.9021	8	10	0.7520	10	5	0.0235
Health parameters									
Fecal egg counts/ewe	1,300	900	0.0317	1,100	1,000	0.0648	1200	700	0.0381
Fecal egg count/lamb	3,000	1,800	0.0211	2,800	1,500	0.0321	2600	1600	0.0451
Tick count/animal	10	0	0.0060	8	5	0.0579	12	0	0.0029
Louse count/animal	0	0	1.0000	4	0	0.0410	4	0	0.0381
Lameness (no sheep per flock)	0	1	0.0709	1	1	0.9616	1	0	0.3201
Abortions (% of pregnancies)	5	4	0.0821	5	4	0.1761	0	2	0.0439
Clinical mastitis (% of ewes)	10	5	0.0011	10	10	1.0000	10	5	0.0276
Antiparasitic use (% of ewes treated)	0	75	4.351^{e-9}	5	50	0.0021	0	100	2.303^{e-11}

Org. organic, *Con.* conventional

* $P \leq 0.05$, probability of significant effects due to production system

in the conventional operations than in the organic systems. Gastrointestinal nematode resistance to anthelmintics in cattle, goat, and sheep in organic systems were 5, 10, and 5 %, respectively, whereas in the conventional system, values were 30, 50, and 70 %, respectively.

Productive parameters

In most years, conventional cows, goats, and sheep usually yielded more milk compared to the organic herds and flocks. Exceptions included the first 2 years of the goat study (2006/2007) and the first year (2008) for cows. The difference in milk production was approximately 18 kg/ha for cows, 26 kg/ha for goats, and 25 kg/ha for sheep less compared to the conventional systems. Conventional farms showed substantially greater productive parameters (body weight gain and lactating animals) in all years (Tables 1, 2, and 3). By contrast, mortality in offspring was lower in cattle in the organic compared to the conventional systems (Tables 1, 2, and 3). The stocking density for all species was less in organic farms than in the conventional farm.

Discussion

The lower milk production per animal, ADG, and percent lactating animals in the organic herds and flocks might be a result of greater predominance of cross-breeding with *Bos indicus* (Gyr) and less use of concentrate compared to the conventional systems. Low milk yield per hectare in the organic herds and flocks were probably due to the less productive breed and low stocking density compared to conventional herd. In tropical countries like Brazil, the organic farmer must choose a less productive breed that is well-adapted to the local environmental conditions, better able to utilize local forages, and more resistant to parasites. Low production rates in tropical organic herds and flocks are a result of multifactorial complex conditions that are difficult to measure in isolation.

Although Brazil presents a great potential for organic production, few studies have compared these to conventional systems. Previous studies (Silva et al. 2011, 2012a, b) reported a greater parasite load in organic goat and cattle. Despite lower milk yields per animal in the organic compared to the conventional systems, the reduction in milk yield is compensated by the greater added value of milk, estimated to increase by 50 to 70 % over conventional milk prices (reference needed).

The results of the trial indicate that gastrointestinal nematodes remain a major constraint associated with the losses in livestock production on pasture. In lactating domesticated ruminants on pasture, gastrointestinal nematode infection reduces production efficiency by decreasing voluntary feed intake, average daily gains, milk yield, and carcass quality (Moreno-Gonzalo et al. 2012). According to Cabaret (2003), helminth infection is usually more intense on organic farms than conventional farms. Our findings support this finding:

organic herds showed greater prevalence of internal parasitism than conventional herds. Likewise, Svensson et al. (2000) reported greater incidence of internal parasitism on organic than conventional farms (17 and 5 %, respectively).

Calves on the organic farm showed lower prevalence of oocyst per gram of feces. Housing calves in stalls and stocking them at heavy rates in the conventional system, despite the mitigating use of veterinary drugs, are two likely contributing factors for high burdens. According to Varghese and Yayabu, coccidiosis is more serious when animals of any age are kept in unhygienic and overcrowded houses or in heavily stocked paddocks (Varghese and Yayabu 1985).

Our results corroborate recent findings from Europe and Brazil, which observed a tendency toward greater parasitism in animals kept on pasture (Silva et al. 2011; Giudici et al. 1999; Hoste et al. 2002). As in the case of our study, the main measures taken by conventional farms to control internal and external parasites in dairy herds are anthelmintic treatments (Hoste et al. 2002) and the extensive use of these chemicals seems to be the origin of parasite resistance to anthelmintics (Molento et al. 2011). As expected, anthelmintic use in our study was less in organic systems (25 %) when compared to conventional systems (83 %). According to Bennedsgaard et al. (2003), the differences in the use of veterinary drugs between organic and conventional herds might be a question of different management priorities.

Although not directly measured, the extensive use of anthelmintic treatments on the conventional system observed in our study (monthly or quarterly in all animals on those farms) might suggest possible high rates of resistance to these chemicals for the three species (cattle, goat, and sheep) evaluated. Thus, the search for alternatives in which animals are not exposed to highly infested pastures, with great nutritional support for more susceptible animals, rotationally grazed pasture, and selective anthelmintic treatments seem viable “green” solutions that may need to be more extensively applied in tropical countries.

Organic farming systems had lower tick and louse counts, a positive effect possibly associated with the difference in breeds and to pasture management. This result agrees with data from Svensson et al. (2000) which showed lower ectoparasite loads in organic cattle kept in temperate areas. However, studies involving production variables such as milk production, average daily gain, as well as animal health parameters in tropical areas are still scarce for organic goats, sheep, and cattle, especially in the tropics.

The greater incidence of abortions in the conventional system probably reflects the reproductive management (artificial insemination) combined with stress level under these conditions compared to organic systems. Studies in livestock have demonstrated that stressful conditions result in low reproductive efficiency (Roche et al. 2000).

The greater incidence of mastitis in conventional herds was probably due to the high milk production capacity observed in these farms. In general, herds with greater milk yield run greater risks of contracting clinical mastitis (Suriyasathaporn et al. 2000).

The annual variations observed on health and production parameters in both systems can be explained due to their recent introduction; except for Pesagro-Rio, all newly established farmers were still in the process of standardizing nutrient, health, and reproductive management. Therefore, such variations were expected. Moreover, forage supply (diet of the animals were predominantly grazing) and concentration of larvae from pasture may have been affected by regional climatic changes occurring during the study.

One of the possible differences in improved health and low parasite loads of organic herds and flocks compared to conventional systems in all three ruminant species are the organic management practices, such as rotational grazing, short periods on pasture and low stocking density (Giudici et al. 1999). This finding also highlights the importance of pasture management as an alternative to the use of chemical products for controlling helminthes observed in other studies (Athanasiadou et al. 2002; Silva et al. 2011, 2012ab).

Organic systems may not be a strategy that solves global limitations in livestock production (Sundrum 2001). These practices, if technically sustainable over time, may mitigate adverse effects on the environment vis-à-vis environmental and human health issues arising from conventional livestock systems (Peter et al. 2005).

In our trial, we observed differences in animal health and production among the two systems. We agree with Benoit and Veysset that assessing differences in these two systems is a complex process that should consider not only management and economic parameters, but numerous environmental factors (Benoit and Veysset 2003). Important variables as well as genetic factors, nutritional quality and parasitism level of the pasture may directly influence the productive and health parameters. From our data collection, we only assessed quantitative inferences that do not permit us to determine such complex interactions, and thus new evaluations require further refinement. Therefore, a large database using statistical multivariate analysis may provide additional information and should be explored. Despite these limitations, our results based on an extended monitoring period provide novel information for organic dairy production in tropical countries.

As in many other Latin America countries, Brazil has a great potential for organic production which is currently not explored. Compared to previous studies conducted in Europe (Giudici et al. 1999; Hoste et al. 2002), the profile of breeds and management of dairy cattle, goat, and sheep in Latin America is very distinct from those in Europe and USA. Finally, we believe that an integrated evaluation of production, nutrition, genetic, health, and economic parameters is the most consistent path to understanding and comparing organic and conventional production system used in Brazil.

Conclusions

Despite lower milk yield observed in organic systems for the three species evaluated, animals in these units were less susceptible to health and management problems. The herds and flocks raised under organic systems had lower offspring mortality, less incidence of mastitis, lower rates of abortions, as well as lower tick and louse counts. Reduced stocking density and rotational pasture management in organic systems likely contributed to lower parasite loads.

In Brazil, nutritional management in organic milk production systems is usually associated with the use of alternative feeds such as forage legumes, which in addition to reducing costs vis-á-vis concentrates, might contribute to cost efficiency especially to small farmers. Despite decreased milk production, the organic systems were superior in health and management, resulting in residue-free milk. Thus, the reduction in milk yield is compensated by the greater added value of milk on the market.

Viewed from a systems perspective, greater added value of milk, reduction in health and management challenges, combined with environmental benefits compensate for reduction in milk production in organic versus conventional dairies. Taken together, these provide an apologia for organic management of dairy herds in warm climates. However, additional research with broader comparisons of production, nutrition, genetics, health, and economics is justified to document tropical production management techniques and risk factors of organic dairy herds.

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Conflict of interest The authors (J.B. Silva, G.M. Fagundes, J.P. Muir and J.P.G. Soares) have no financial or personal relationship with other people or organizations that could inappropriately influence or bias the research.

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