An Acad Bras Cienc (2021) 93(2): e20191048 DOI 10.1590/0001-3765202120191048
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

ANIMAL SCIENCE

Performance of broiler breeders supplemented with organic and inorganic minerals

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Abstract: The present study aimed to evaluate the use of organic and inorganic minerals in Cobb500 broiler breeder diet and its effects on the performance. The birds were housed in an experimental house at Poultry Laboratory of the Federal University of Santa Maria with 20 floor pens of 4.61m2 each. The experiment was conducted between 51st and 65th weeks of age of birds. The design was completely randomized with four treatments and five pen replicates with 22 hens and 2 roosters each. The treatments evaluated were: PI=100% mineral inorganic premix; PO= 100% mineral organic premix: PI+PO= 70% mineral inorganic premix + 30% mineral organic premix and PI+Zn= 100% mineral inorganic premix, except zinc mineral, that was 70% inorganic form and 30% organic form. The following parameters of performance and egg quality were evaluated: laying rate, body weight, egg, albumen and yolk weight, yolk color and specific gravity of eggs. These parameters were performed one day per week throughout the experimental period to evaluated egg quality. Under the conditions and time that the experiment was conducted, the use of organic minerals had no significant effect on the performance and egg quality parameters evaluated in the broiler breeders.

Key words: Egg quality, laying rate, specific gravity, trace mineral.

INTRODUCTION

The trace minerals or micro minerals such as zinc (Zn), iron (Fe), copper (Cu), selenium (Se), iodine (I) and manganese (Mn), are involved in many biochemica functions, physiologic and endocrine functioning as catalysts for enzymatic processes, secretion of hormones and immune responses and are essential for the growth and health of the poultry. From a practical standpoint these minerals have been added to the diets with large safety margins for the broiler breeders express their maximum genetic potential. Historically this occurs due to low cost mineral in its inorganic form and the lack of accurate requirements data on of these minerals (Zhao et al. 2010).

Most mineral sources added to feed are derived from inorganic compounds such as of inorganic salts, such as sulfates, oxides, and carbonates (Bao et al. 2007). Organic micro mineral sources may be an alternative to inorganic sources. Organic trace minerals do not dissociation in the acidic gastric pH, remaining electrically neutral and protected from chemical reactions with other molecules in the intestinal lumen, which optimizes their absorption and increases their bioavailability relative to inorganic sources (Swiątkiewicz et al. 2014).

The advantage in using organic minerals is that they do not form insoluble complexes

in the stomach because they are protected from interaction with the feed or the actual components present in the digestive tract (Abdallah et al. 2009).

The higher bioavailability compared to conventional inorganic sources, by the organic complexes have been the motivation for increasing the researches in the area. Considering that they are more easily absorbed and accumulated by the poultry, and in addition to acting by improving performance and reducing the excretion of trace minerals that are potentially polluting the environment (Carvalho et al. 2015).

Araújo et al. (2019) evaluated the Different dietary trace mineral sources for broiler breeders and reported that organic trace mineral (OTM) supplementation improved broiler breeder performance, with by higher egg production and better eggshell quality of OTM-fed hens compared with those fed inorganic trace mineral.

The object of this study was to evaluate the effects of the replacing different levels of organic and inorganic minerals (Zn, Cu, I, Fe, Mn and Se) on the diet of broiler breeders on the egg production e and egg quality.

MATERIALS AND METHODS

Broiler Breeders

The present study was carried out at the Poultry Science Laboratory - LAVIC of the Federal University of Santa Maria (UFSM). All procedures used in this study were previously submitted and approved by the Ethics Committee of UFSM (CEUA Nº 8311011116). The experiment evaluated the productive performance of Cobb500 broiler breeders submitted to the use of organic and inorganic mineral feed in 4 experimental groups.

The experimental period comprised the interval between the 51st and 65th week of age. Information was collected regarding the laying rate, egg, yolk and albumen weight and specific gravity of eggs. Except of egg production, which was collected daily, the other parameters were measured weekly. In a total of 440 hens and 40 roosters of broiler breeders were used and distributed on a completely randomized design with four treatments and five replicates of 22 hens and two roosters each. The hens were housed in their treatment according to body weight and rate of laying. The roosters were selected and divided according to their phenotypic characteristics, such as: body weight and phenotypic characteristics. The birds were housed in experimental poultry house, with a total area of 300m2, being used for the experiment 20 boxes of 4.61m2 (3.24 x 1.42 m) each. Water was supplied ad libitum throughout the experimental period, and the drinkers were washed three times a week. A photoperiod of 16 hours light/day was used during the study.

Treatments

The broiler breeders were subjected to four different treatments, according to Table I. The micro minerals utilized on diet were: cobre (Cu), selenium (Se), iron (Fe), manganese (Mg) and zinc (Zn). PI treatment - consisting of 100% inclusion of inorganic mineral premix; PO treatment - 100% inclusion of organic mineral premix; treatment PI+PO - 70% inclusion of inorganic mineral premix and 30% organic and mineral premix; treatment PI+Zn - 100% of inorganic mineral premix (except zinc: 70% inorganic zinc, plus 30% organic zinc). The basal diet was formulated taking into account the nutritional requirements proposed by Rostagno (2011), as shown in Table II.

The diet was feed to the birds by the morning every day at 8 o'clock in a controlled manner; the total consumption volume was calculated daily according to the number of hens and roosters/box and the amount of feed

Table I. Treatments involving broiler breeders and different minerals.

Premix			
Treatments	**Premix Organic[2], (%)**	**Premix Inorganic, (%)**	**Zinc Organic, (%)**
PI	0	100	0
PO	100	0	0
PI+PO	30	70	0
PI+Zn	0	100[1]	30

[1]Except for Zinc, that is 70%.
PI= 100% premix mineral inorganic: Cu, 300mg; Fe, 1500mg; Mg 2100mg; Se, 9mg; Zn, 1950mg per kg of diet.
PO= 100% premix mineral organic: Cu, 500mg; Fe, 3500mg; Mg 4000mg; Se, 16mg; Zn, 5500mg per kg of diet.
PI+PO= 70% premix mineral inorganic (Cu, 210mg; Fe, 1.050mg; Mg 1.470mg; Se, 6.3mg; Zn, 1.365mg per kg of diet). + 30% premix mineral organic (Cu, 150mg; Fe, 1050mg; Mg 1200mg; Se, 4.8mg; Zn, 1650mg per kg of diet).
PI+Zn= 100% premix mineral inorganic (Cu, 300mg; Fe, 1500mg; Mg 2100mg; Se, 9mg per kg of diet), except zinc mineral, that is 70% inorganic form and 30% organic form (1365mg +1650mg per kg of diet, respectively).
[2] Yes Sinergy Brazil.

in grams to be supplied the week, based on the recommendations of the Cobb 500 manual. The roosters ate the same diet of hens in separate feeders following the daily amounts of manual Cobb.

Hens performance and eggs quality

Every two weeks 50% of hens and 100% of roosters were weighed. 100% of the birds were weighed, individually, every 28 days, the birds even in the fasted state and with the use of a scale pointer with a capacity of 10kg and accuracy of 50g.

The eggs of the 51st until the 65th week were daily collected six times a day and identified with a pencil at the end of each collection, with the number of replicate pen in which they originated. The laying rate (RL) of each replicate was calculated weekly using the formula:

RL: (number of eggs produced / average number of birds in the week) X 100

One day a week, eggs were selected and classified those who not had abnormalities in form, cracks, dirt and small or excessively large eggs. Posteriorly, this eggs were used for obtain the weight and specific gravity. These evaluations were conducted utilizing all eggs produced during the last day of the week. Specific gravity was determined through the immersion of the eggs in saline solutions with densities of 1.065; 1.070; 1.075; 1.080; 1.085; 1.090 and 1.095g/cm3 (Hamilton 1982). The yolk color was measured using the DSM Yolk Color Fan. Egg weight, yolk weight and albumen weight were determinate through a precision scale (0.001g).

Statistical analysis

Data were submitted to analysis of variance and means compared by Tukey test at 5% significance level. These statistical procedures were performed by the statistical program SAS (Statistical Analysis System, 2000).

RESULTS AND DISCUSSION

Hens performance and eggs quality

The results obtained with the addition of different sources of mineral premix in the diets of broiler breeders showed no significant effect (P>0.05) on egg production in the period between 51st and 65th weeks of age (Table III). In this way, the results of this study are consistent with those obtained by Carvalho et al. (2015) that not found effect on the egg production of layers of the inclusion in the basal diet of a mixture of organic trace minerals (copper, iron,

Table II. Ingredient composition and calculated nutrient analysis of the basal diets of broiler breeder.

Ingredient, (g/kg)	Amount
Corn grain	68.52
Soybean meal (46% Crude Protein)	21.57
Wheat bran	0.11
Dicalcium phosphate	16.4
Limestone	7.21
Salt	0.40
Vitamin Premix[1]	0.40
Mineral Premix[2]	0.10
DL-Methionine	0.40
Calculated analyses	
Energy Metabolize, (kcal/kg)	2850
Crude Protein (%)	15.96
Calcium (%)	3.00
Available phosphorus (%)	0.40
Cooper (mg/Kg)	12.00
Iron (mg/Kg)	60.00
Zinc (mg/Kg)	78.00
Selenium (mg/Kg)	0.36
Manganese (g/Kg)	84.00

[1]Vitamin premix: Composition per kilogram of product: vitamin A, 2.090.000 UI; vitamin E 7.600mg; vitamin, B1 475mg; vitamin, D3 332.500 UI; vitamin, K3 950mg; nicotinic acid, 8.500mg; vitamin, B12 3.800mcg; vitamin, B2 1.900mg; vitamin, B6 950mg; folic acid, 237.5mg; biotin, 38mg; choline, 72.000mg; pantothenic acid, 3.800mg;
[2]Mineral premix: Composition per kilogram of product: copper, 3.000mg; iron, 15.000mg; iodine, 300mg (in salt); manganese, 21.000mg; selenium, 90mg; zinc, 19.500mg.

manganese and iodine, chelated with amino acid and partially hydrolyzed proteins) replacing 100%, 90%, 80%, or 70% of the inorganic mineral source.

The body weight of broiler males and females, were not affected during the experimental period. Bao et al. (2007), experimenting with broilers using 4 mg of copper and 40 mg each of iron, manganese and zinc, reported no effect on body weight and growth, it is possible to use these low levels of organic minerals and reduce the excretion into the environment.

To rate of laying, the results agree with those obtained by Sechinatto & Nakada (2006), that experimented with layer hens and the results of treatments with diets containing 100% organic minerals and 100% inorganic minerals and even diets with the combination of an organic single element, whether (Mn, Fe, Zn, Cu, Se) and others inorganic minerals, had no benefit on production parameters. As well as, Yenice et al. (2015) found no difference in the effects of dietary organic (chelated) or inorganic Mn, Zn, Cu and Cr supplementation on the performance (body weight, egg weight, and egg production) of laying breeder hens.

The use of organic micro mineral in animal diets has been increasing because they appear to have greater bioavailability compared with inorganic micro mineral (Cao et al. 2002). Organic micro minerals present good chemical stability, higher biological potency and delay the antagonism among different minerals (Spears 1996). In this study, this positive effect of the substitution or addition of organic minerals in the bird diet was not found. Egg production remained the same, so the use of minerals in organic form can be done without causing negative effects on performance.

Using different sources of selenium and organic zinc, Reis (2009) did not observe significant differences in average egg weight and specific gravity of eggs from broiler breeder's production in two periods. Studies comparing sources of inorganic and organic selenium to egg weight are contradictory. Leeson et al. (2008), using inorganic versus organic selenium did not affect laying rate or egg weight of broiler breeders or layer hens, which is in agreement with the previous findings of Utterback et al. (2005). This author states that despite the results, the use of organic form in the diets of hens increases the selenium content in eggs.

In this study, the egg quality (specific gravity, weight of egg, yolk and albumen) was also not affected by the use of organic minerals.

Table III. Egg production, constituents and specific gravity.

Period (weeks)	Treatments	Egg Production (%)	Egg weight (g)	Specific Gravity (g/cm3)	Yolk color	Yolk (%)	Albumen (%)
	PI PI	68.28	70.84	1.083	8.68	56.67	30.80
	PO	67.86	70.63	1.083	8.90	57.07	30.88
51-54	PI+PO	67.15	70.64	1.083	8.53	56.93	30.66
	PI+Zn	67.04	70.94	1.082	8.71	56.85	30.80
	SEM	0.56	0.21	0.0002	0.09	0.19	0.16
	P-value	0.8675	0.9529	0.7290	0.5905	0.9204	0.9736
	PI	63.44	70.48	1.080	9.63	56.81	30.88
	PO	60.84	70.14	1.079	9.63	56.92	30.91
55-58	PI+PO	59.56	71.19	1.079	9.40	57.25	30.74
	PI+Zn	61.27	70.71	1.079	9.43	56.53	31.09
	SEM	0.89	0.21	0.0001	0.11	0.12	0.12
	P-value	0.5140	0.3824	0.4196	0.8336	0.2555	0.8444
	PI	57.56	70.83	1.080	10.80	56.54	31.02
	PO	58.50	71.07	1.079	10.61	56.97	31.19
59-62	PI+PO	58.28	72.23	1.079	10.80	56.66	31.17
	PI+Zn	56.94	71.49	1.079	10.46	56.67	31.21
	SEM	1.01	0.25	0.0002	0.06	0.16	0.18
	P-value	0.9553	0,2496	0.6875	0.2357	0.8487	0.9851
	PI	52.97	70.64	1.079	10.51	56.74	30.58
	PO	51.49	71.40	1.079	10.66	57.16	30.48
63-65	PI+PO	53.07	71.90	1.079	10.55	57.24	30.57
	PI+Zn	52.86	71.46	1.078	10.37	56.32	31.13
	SEM	0.80	0.19	0.0002	0.09	0.19	0.16
	P-value	0.9026	0.1314	0.7554	0.7840	0.3238	0.5446
	PI	61.07	70.70	1.080	9.86	56.69	30.85
	PO	60.22	70.77	1.080	9.90	57.02	30.89
Total	PI+PO	59.95	71.46	1.080	9.77	57.00	30.80
	PI+Zn	59.97	71.13	1.080	9.70	56.63	31.05
	SEM	0.74	0.17	0.0001	0.05	0.11	0.10
	P-value	0.9549	0.4166	0.5034	0.6243	0.5409	0.8759

PI= 100% premix mineral inorganic.
PO= 100% premix mineral organic.
PI+PO= 70% premix mineral inorganic + 30% premix mineral organic.
PI+Zn= 100% premix mineral inorganic, except zinc mineral (70% inorganic form and 30% organic form).

This effect has also been observed by Stefanello et al. (2014) who evaluated the quality of eggs on Hy-Line W36 laying hens between 47 to 62 wk of age fed diets supplemented with an organic source (proteinates) of micro minerals (Mn, Zn, and Cu) and no found effect of micro minerals on the specify gravity. Also, Saldanha et al. (2009) evaluated effect of organic mineral

supplementation (Zn, Fe, Mn, Cu, I, and Se) on the egg quality of semi-heavy layers and did not find significantly influenced by the treatments on the yolk and albumen percentage. However, this same author found significantly influenced egg specific gravity and eggshell percentage, with the 80% organic micro mineral level. Paik (2001) evaluated organic Zn, Cu, and Mn sources in layer diets, and observed higher specific gravity and eggshell percentage in the eggs of layers fed organic micro minerals, and the association between organic Zn and Mn improved eggshell strength. According to author Zn influenced the synthesis of the enzyme carbonic anhydrase, which is essential for eggshell formation. However, in this study we sin not to evaluate the thickness of the shell, which would give us more specific results about the real quality of the shell and the influence of micro minerals on its deposition.

Branton et al. (1995), found better results in the percentage of laying rate, which differ from those found in this study, in birds treated with organic minerals. Similar results were also found by Surai (2002), Rutz et al. (2006). Pan et al. (2004) also found positive results in the use of organic minerals, in laying hens, using selenomethionine and observed an improvement in production and egg weight, yolk color and albumen quality. In this study, the yolk color was also not affected by the use of organic minerals. However, studies performed by Pan et al. (2010) with semi- heavily laying hens supplemented with Se organic demonstrated an improvement on the yolk coloration. These results are in agreement with those of (Surai & Sparks 2000) which, by adding organic selenium in the mother's diet, observed an increase of carotenoids, vitamin A and vitamin E in the liver of chicks born. The positive effect of organic selenium on these fat-soluble substances may have occurred at both the level of intestinal absorption as in its transport in fluid extracellular to the liver or follicle. This fact justifies the observation of the yolk color in this study, since Se added to diet can promote color change.

Surveys of long duration with broilers breeders are very limited and the literature is controversial as to the results of evaluations of the use of organic minerals in commercial broiler breeders. This suggests further research on the subject, and because most authors state that but no differences on evaluated parameters in broiler breeder, studies indicated that organically-bound trace minerals can enhance mineral uptake, increase the mineral concentrations in the circulatory system or tissues, and reduce mineral excretion compared to inorganic mineral forms (Abdallah et al. 2009, Surai et al. 2006). With increasing concerns related to mineral pollution from animal waste, there has been considerable interests and discussion on how to minimize the excretion from the animal production Wang et al. (2018). Thus, the focus of research involving organic minerals should be on environmental issues and sustainability.

According Wang et al. (2018), the sources and levels of dietary supplemental trace minerals influence the concentration of minerals in serum, tissues, and fecaluria. In your study, organic trace minerals showed better retention than inorganic minerals. Supplementing the basal diet with organic trace minerals at 62.5% of commercially recommend level resulted in the highest retention in serum and tissues, while also reducing mineral excretion in fecaluria to levels equivalent or lower than the two inorganic treatments (50% and 37.5% of the inorganic trace minerals).

CONCLUSION

Under the conditions and time that the experiments were conducted, the use of organic minerals in broiler breeders diets had not significant effects on the egg production, constituents and specific gravity.

REFERENCES

ABDALLAH AG, EL-HUSSEINY OM & ABDEL-LATIF KO. 2009. Influence of some dietary organic mineral supplementations on broiler performance. Inter J Poul Sci 8: 291-298.

ARAÚJO CSS, HERMES RG, BITTENCOURT LC, SILVA CCL, ARAÚJO F, GRANGHELLI CA, PELISSARI PH, ROQUE FA & LEITE BGS. 2019. Different dietary trace mineral sources for broiler breeders and their progenies. Poult Sci 98(10): 4716-4721.

BAO Y, CHOCT M, IJI PA & BRUERTON K. 2007. Effect of organically complexed copper, iron, manganese, and zinc on broiler performance, mineral excretion, and accumulation in tissues. J Appl Poult Res 16: 448-455.

BRANTON SL, LOTT BD, MASLIN WR & DAY EJ. 1995. Fatty liver-hemorrhagic syndrome observed in commercial layers fed diets containing chelated minerals. Avian Diseases 39: 631-635.

CAO J, HENRY PR, DAVIS SR, COUSINS RJ, MILES RD, LITTLE RC & AMMERMAN CB. 2002. Relative bioavailabity of organic zinc sources based on tissue zinc and metallothionein in chicks fed conventional dietary zinc concentrations. Anim Feed Sci Technol 101: 161-170.

CARVALHO LSS, ROSA DRV, LITZ FH, FAGUNDES NS & FERNANDES EA. 2015. Effect of the inclusion of organic copper, manganese, and zinc in the diet of layers on mineral excretion, egg production, and eggshell quality. Braz J Poult Sci 87-92.

HAMILTON RMG. 1982. Methods and factors that affect the measurement of egg shell quality. Poult Sci 61: 2022.

LEESON S, NAMKUNG H, CASTON L, DUROSOY S & SCHLEGEL P. 2008. Comparison of Selenium Levels and Sources and Dietary Fat Quality in Diets for Broiler Breeders and Layer Hens. Poult Sci 87: 2605-2612.

PAIK I. 2001. Application of chelated minerals in animal production. J Anim Sci 14: 191-198.

PAN EA, RUTZ F, DIONELLO NJL, ANCIUTI MA & DA SILVA RR. 2004. Performance of brown egg layers fed diets containing organic selenium (Sel- Plex®). In: Nutritional Biotechnology in the Feed and Food Industries. Proceedings of the 20th Annual Symposium. Lexington, Ky, May 24-26, p. 18.

PAN EA, RUTZ F, DIONELLO NJL, ANCIUTI M & KRABBE EL. 2010. Desempenho de poedeiras semi pesadas arraçoadas com a suplementação de Selênio orgânico. Rev Bras Agrociência 16: 83-89.

REIS RN, VIEIRA SL, NASCIMENTO PC, PENÃ JE, BARROS R & TORRES CA. 2009. Selenium contents of eggs from broiler breeders supplemented with sodium selenite or zinc-L-selenium-methionine. J Appl Poult Res 18: 151-157.

ROSTAGNO HS. 2011. Tabelas brasileiras para aves e suínos. UFV - 3 ed. Viçosa, MG, 252 p.

RUTZ F, ANCIUTI MA, RECH JL & XAVIER AG. 2006. Following response to (Sel-Plex®) and other organic minerals trough the broiler breeder maze: case studies in Brazil. In: Altechs 22th Annual Nutritional Biotechnology in the Feed and Food Industries. Nottinghann University Press, Loughborough, U.K., p. 502-513.

SALDANHA ESPB, GARCIA EA, PIZZOLANTE CC, FAITTARONE ABG, SECHINATO A, MOLINO AB & LAGANÁ C. 2009. Effect of organic mineral supplementation on the egg quality of semi-heavy layers in their second cycle of lay. Braz J Poult Sci 11(4): 215-222.

SAS Institute Inc. 2000. SAS user´s guide: Statistics. Version 8 Edition. SAS Institute Inc., Cary, NC.

SECHINATTO AS & NAKADA AS. 2006. Efeito da suplementação dietética com micro minerais orgânicos na produção de galinhas poedeiras. Braz J Vet Res Anim Sci 43: 159-166.

SPEARS JW. 1996. Organic trace minerals in ruminant nutrition. J Anim Sci Technol 58: 151-163.

STEFANELLO C, SANTOS TC, MURAKAMI AE, MARTINS EM & CARNEIRO TC. 2014. Productive performance, eggshell quality, and eggshell ultrastructure of laying hens fed diets supplemented with organic trace minerals. Poult Sci 93: 104-113.

SURAI PF. 2002. Effect of selenium and vitamin E and content of the maternal diet on the antioxidant system of the yolk and the developing chick. Poult Sci Champaing 41: 235-243.

SURAI PF, KARADAS F, PAPPAS AC & SPARKS NHC. 2006. Effect of organic selenium in quail diet on its accumulation in tissues and transfer to the progeny. Br Poult Sci 47(1): 65-72.

SURAI PF & SPARKS NHC. 2000. Effect the selenium content on the maternal diet on the antioxidant system of the yolk. British Society of Animal Science 41(2): 235-243.

ŚWIĄTKIEWICZ S, ARCZEWSKA-W Ł OSEK A & JOZEFIAK D. 2014. The efficacy of organic minerals in poultry nutrition: review and implications of recent studies. Worlds Poult Sci J 70: 475-486

UTTERBACK PL, PARSONS CM, YOON I & BUTLER J. 2005. Effect of supplementing selenium yeast in diets of laying hens on egg selenium content. Poult Sci 84: 1900-1901.

WANG G, LIU L, WANG Z, PEI X, TAO W, XIAO Z, LIU B, WANG M, LIN G & AO T. 2018. Comparison of Inorganic and Organically Bound Trace Minerals on Tissue Mineral Deposition and Fecal Excretion in Broiler Breeders. Biol Trace Elem Res 189(3): 1-9.

YENICE E, MIZRAK C, GÜLTEKIN M, ATIK Z & TUNCA M. 2015. Effects of dietary organic or inorganic manganese, zinc, copper and chrom supplementation on the performance, egg quality and hatching characteristics of laying breeder hens. Ankara Üniv Vet Fak Derg 62: 63-68.

ZHAO J, SHIRLEY RB, AMON MV, RICHARDS JD, FISHER P, HAMPTON T, CHRISTENSEN KD, ALLARD JP & GIESEN AF. 2010. Effects of chelated trace minerals on growth performance, breast meat yield, and footpad health in commercial meat broilers. J Appl Poult Res 19: 365-372.

How to cite

PEDRO D, ROSA AP, LONDERO A, FORGIARINI J, BRANCO T, FREITAS HM, GIACOMINI CBS & PILECCO M. 2021. Performance of broiler breeders supplemented with organic and inorganic minerals. An Acad Bras Cienc 93: e20191048. DOI 10.1590/0001-3765202120191048.

Manuscript received on July 22, 2019;
accepted for publication on November 7, 2019

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