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CHARACTERIZATION OF THE BACKYARD CHICKEN PRODUCTION SYSTEM IN CAMPECHE STATE, MEXICO

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ABSTRACT

A study was conducted to characterize the backyard chicken production system in Campeche State, Mexico, as the basis of a program for utilizing local poultry genetic resources. A total of 260 surveys were administered in person. The parents undertake backyard production activities. Farmers have, on average, 0.20 ± 0.1 hectares for raising local chickens (LC). Flock size was 24.4 ± 1.3 birds per household. The number of egg/hen/year was 45.8 ± 1.6. Confined and semi-confined production systems are used. Farmers fed chickens with corn, whereas chicks were fed with commercial feed. During the rainy season, flu and diarrheal diseases are more frequently observed. Body size is the main trait for acquiring/selecting breeders within/outside the flock. Selection of eggs for incubation is based on size and freshness. Feed shortages, diseases, predators, and lack of technical assistance services were the major constraints for LC backyard production. In conclusion, backyard chicken production based on LC provides a readily available source of animal protein and cash income for households in Campeche State, Mexico.

Keywords: ecoregion, household income, local chickens, management of local chickens, rural people.

INTRODUCTION

Backyard poultry farming is an important activity in the rural zones of Mexico; this activity is considered an additional source of household income and is carried out primarily by housewives, children and senior citizens (Cuca-García *et al.,* 2015). This animal production system is based on local chickens (LC), that is, birds that presumably descend from those brought to Mexico by the Spaniards in the XV century (Valadez, 2003). Local chickens provide household livelihood security, animal protein and economic income (McAinsh *et al.,* 2004; Padhi, 2016). It has been argued that LC are able to survive and produce meat and eggs under harsh environments, poor nutrition profiles and deficient sanitary conditions (Dessie *et al.,* 2011; Padhi, 2016). However, the productive performance of these birds is low (Okeno *et al.,* 2012). Almost half of the population in Campeche State, Mexico, lives in poverty and it is estimated that 25.0% are located in rural areas (INEGI, 2010; CONEVAL, 2016). The characteristics of the backyard poultry system could have

variations among regions within the State. In fact, there is limited information about LC-raising practices in this State of Mexico, and this issue has been addressed by a small number of researchers (Candelaria-Martínez *et al.,* 2016; Flota-Bañuelos *et al.,* 2016). The present investigation is an effort to characterize this animal production system as a step forward in the development of improvement strategies, including for breeding and genetic purposes. These strategies could lead to higher LC productivity, which in turn could improve the quality of life of the rural population in Campeche State, Mexico. Thus, the aim of this study was to characterize the backyard chicken production system in Campeche State, Mexico, in terms of characteristics and constraints. Specific areas covered include production systems, housing conditions for birds, management and feeding, health, reproduction, and constrains for raising of LC. This information is intended to serve as the basis for the development of a program aimed at improving local poultry genetic resources.

MATERIALS AND METHODS

Study Sites

This study was conducted in Campeche State, located in southeastern Mexico on the Yucatan Peninsula. In order to carry out the sampling process, the ecological and biogeographical regionalization reported by CONABIO (2007) was used. Four ecoregions were sampled: wetlands of northern Yucatan (WNY), central plain of Yucatan (CPY), low hills of southern Yucatan (LHSY), and wetlands of the southern Gulf of Mexico (WSGM). Most of the territory (99.7%) has a warm humid to subhumid climate. Temperature ranges from 18.0°C to 30.0°C; abundant rains occur during the summer (June to September), with total annual precipitation ranging from 1,200 to 2,000 mm (INEGI, 2014). This study was conducted from June to December 2016.

Sampling Procedure

To determine sample size in each ecoregion, the following methodology described by FAO (2012) for phenotypic characterization of animal genetic resources was used:

$$n = \frac{\left(\frac{z}{m}\right)^2 p(1-p)}{1 + \frac{\left(\frac{z}{m}\right)^2 p(1-9)}{N}}$$

where z is the z value (1.95 for 95% confidence level); m is the margin of error (0.05); p is the estimated value for the proportion of the sample that will respond in a given way to a survey question (0.50); n is the sample size; and N is population size [number of dwellings inhabited as reported by SEDESOL (2015)]. Using this criterion, 29, 153, 24 and 54 households were selected from the WNY, CPY, LHSY and WSGM ecoregions, respectively. In each ecoregion, three communities were randomly selected. Within each selected community, a non-probabilistic snowball sampling method (Goodman, 1961) was used to identify farmers that raise LC.

Survey Application

A total of 260 surveys were administered in the four ecoregions. A well-structured survey was designed with closed questions to collect information on: farm size and livestock composition, flock structure and productive performance, production system and housing conditions for LC, feeding and sanitary management, breeding methods and selection criterion and constraints when these birds are raised. The purpose of the interview was fully explained to each respondent, and subsequently the survey was applied.

Statistical Analysis

Farm size, livestock species, flock structure, performance of chicken and age at sexual maturity were analyzed with the PROC MEANS of SAS Institute Inc. (version 9.3, 2011). The effect of the ecoregion on the different variables was estimated using the model below:

$$y_{ij} = \mu + eco_i + \varepsilon_{ij}$$

where y_{ij} is the dependent variable, μ the overall population mean, eco_i the ecoregion effect (i=WNY, CPY, LHSY and WSGM) and ε_{ij} the random residual effect.

Rest of the variables were analyzed with the PROC FREQ of SAS Institute Inc. (version 9.3, 2011).

RESULTS

Farm Size and Livestock Composition

Farm size was 0.20 ± 0.1 hectares where the most important livestock species were LC, followed by turkeys and ducks. The number of livestock species was different among ecoregions (P <0.01); in the LHSY ecoregion a greater number of sheep was found compared to the other ones (Table 1). Additionally, the main reason for raising LC reported by farmers was to obtain a source of food (83.1%), followed by selling their surplus products (chickens and eggs) for cash (14.2%). Only farmers in the WNY and WSGM ecoregions raise LC as ornamental birds (2.7%).

Flock Structure and Productive Performance

In this study, flock size was 24.4 ± 1.3 birds per household (Table 1). In the CPY ecoregion a greater number (P <0.01) of hens was found than in the other ecoregions. Flock structure was dominated by hens (8.7 ± 0.6), followed by pullets (4.8 ± 0.4), cockerels (4.8 ± 0.4), chicks (3.8 ± 0.4), and cocks (2.3 ± 0.2), with a sex ratio of four hens per cock (Table 2).

The number of eggs/hen/year was 45.8 ± 1.6 and egg weight was 54.9 ± 5.0 g; these eggs were produced in 2.9 ± 0.1 clutches of 15.3 ± 0.4 eggs each. Eighty-six percent (13.2 ± 0.2 eggs) of the produced eggs were incubated with a hatchability of 75.0% (9.9 ± 0.2 chicks); however, only 84.8% (8.4 ± 0.2 chicks) of the hatched chicks were weaned, and these birds reached sexual maturity at around six months of age (Table 2).

Table 1. Farm characteristic and livestock composition.

Variables	Ecoregions				Overall mean	Sig. (*P*-value)
	WNY (n = 29)	CPY (n = 153)	LHSY (n = 24)	WSGM (n = 54)		
Farm size (ha)	0.10 ± 0.2	0.10 ± 0.1	0.30 ± 0.3	0.60 ± 0.2	0.20 ± 0.1	0.11
Livestock species						
Local chicken	25.8 ± 4.0	25.5 ± 1.7	27.4 ± 4.4	18.9 ± 2.9	24.4 ± 1.3	0.12
Turkey	6.7 ± 1.6	5.4 ± 0.7	6.9 ± 1.8	5.0 ± 1.1	5.6 ± 0.53	0.70
Duck	3.3 ± 1.2	1.7 ± 0.5	0.2 ± 1.4	3.1 ± 0.9	2.0 ± 0.4	0.16
Cattle	1.4 ± 1.1^{ab}	0.1 ± 0.5^{b}	3.9 ± 1.3^{a}	2.1 ± 0.8^{ab}	1.0 ± 0.4	0.01
Sheep	0.1 ± 1.1^{b}	1.2 ± 0.5^{b}	5.5 ± 1.3^{a}	0.5 ± 0.8^{b}	1.3 ± 0.4	0.01
Pig	0.3 ± 0.5^{b}	0.9 ± 0.2^{ab}	2.3 ± 0.6^{a}	0.4 ± 0.4^{b}	1.0 ± 0.2	0.04
Reasons for raising LC						
Consumption	82.8	87.6	87.5	68.5	83.1	
Cash income	13.8	12.4	12.5	20.4	14.2	
Ornament	3.4	-	-	11.1	2.7	

^{a,b} Row means with different superscripts differ significantly at P < 0.05; - not observed; ± standard error of means (SEM); Sig.: Significance; %: percentage; ha: hectares; WNY: wetlands of northern Yucatan; CPY: central plain of Yucatan; LHSY: low hills of southern Yucatan; WSGM: wetlands of the southern gulf of Mexico.

Production System of the Birds and Housing Conditions

Most of the farmers raised the birds under confined and semi-confined systems (80.1%). Chicken coops were predominantly built with wire mesh (59.6%) as walls, galvanized steel sheets (57.2%) as roofs, and a dirt floor (72.9%). Farmers offered feed directly on the dirt floor (36.6%) and water in recycled containers (59.5%); in the same context, hens laid eggs on the dirt floor and in cardboard boxes (50.2 and 31.9%, respectively; Table 3).

Management and Feeding

Mothers (76.3%) and fathers (14.4%) are the family members who take care of the birds; they feed them two to three times a day (35.6 and 58.3%, respectively). The chickens (> four weeks of age) are fed with corn (whole, broken or dough; 50.6%) and chicks (zero to four weeks of age) receive commercial feed (71.6%) and corn or dough (10.9%). Only scavenging chickens are supplemented with corn (whole, dough or tortilla) and wheat bran (74.2%), in order to improve production (meat and eggs; 38.9%), growth (24.4%) and health (36.7%). Additionally, 72.9% of farmers provide drinking water to their chickens, and the rest well-water (Table 4).

Sanitary Management

Most LC farmers (75.1%) clean their chicken coops at least once a week. Likewise, the majority of farmers do not vaccinate (69.3%) but deworm (61.7%) their birds. Rain (43.7%) is the principal factor associated with the period of time with the highest incidence of diseases, which coincides with the rainy season from June to September (44.1%). Flu and diarrhea are the diseases most frequently observed (46.9%). These diseases are controlled with drugs (50.7%) and home remedies

Table 2. Local chicken flock structure and productive performance.

Variables	Ecoregions				Overall mean	Sig. (*P*-value)
	WNY (n = 29)	CPY (n = 153)	LHSY (n = 24)	WSGM (n = 54)		
Flock Structure						
Cocks (> 21 weeks age)	2.5 ± 0.5	2.2 ± 0.2	1.5 ± 0.5	2.7 ± 0.3	2.3 ± 0.2	0.29
Hens(> 21 weeks age)	9.2 ± 1.8[b]	10.2 ± 0.8[a]	6.0 ± 2.0[b]	5.2 ± 1.3[b]	8.7 ± 0.6	0.01
Pullets (4 to 21 weeks age)	4.8 ± 1.3	4.8 ± 0.6	7.8 ± 1.4	3.6 ± 0.9	4.8 ± 0.4	0.27
Cockerels (4 to 21 weeks age)	5.4 ± 1.3	4.5 ± 0.6	7.1 ± 1.4	4.1 ± 0.9	4.8 ± 0.4	0.10
Chicks (0 to 4 weeks age)	3.9 ± 1.3	3.8 ± 0.6	5.0 ± 1.4	3.3 ± 1.0	3.8 ± 0.4	0.79
Flock sex ratio (female:male)	3:1	5:1	4:1	2:1	4:1	
Performance of chickens						
Egg/hen/year	47.8 ± 4.9	45.5 ± 2.1	47.3 ± 5.4	45.1 ± 3.6	45.8 ± 1.6	0.96
Clutches/hen/year	2.9 ± 0.2	2.9 ± 0.1	2.9 ± 0.2	3.2 ± 0.2	2.9 ± 0.1	0.39
Egg/hen/clutch	16.7 ± 1.3	15.2 ± 0.6	15.2 ± 1.4	15.2 ± 1.0	15.3 ± 0.4	0.75
Eggs incubated (%)	74.9	83.6	99.3	92.1	86.0	
Chicks hatched (%)	72.8	76.4	74.2	73.6	75.0	
Chicks weaned/hen/clutch (%)	86.8	86.6	83.0	81.6	84.8	
Age at sexual maturity (months)						
Hens	6.2 ± 0.4	6.3 ± 0.2	6.5 ± 0.4	5.7 ± 0.4	6.2 ± 0.1	0.25
Cocks	5.7 ± 0.4	6.0 ± 0.3	6.2 ± 0.4	6.1 ± 0.3	6.0 ± 0.1	0.84

[a,b] Row means with different superscripts differ significantly at P < 0.05; ± standard error of means (SEM); Sig.: Significance; WNY: wetlands of northern Yucatan; CPY: central plain of Yucatan; LHSY: low hills of southern Yucatan; WSGM: wetlands of the southern gulf of Mexico.

(33.0%). Chicks (zero to four weeks of age) are more susceptible (47.8%) than the rest of the flock (Table 5).

Breeding Practices in Local Chickens

Only a small proportion of the farmers (16.5%) try to improve the productivity of their LC by breeding methods. These methods include selecting within the flock (83.9%) or acquiring improved breeds (16.1%). Body size is the main trait that is taken into account to acquire breeders (hens and cocks) outside the flock or select them from among the farmer's birds. Farmers select eggs based on size (49.2%) and freshness (46.6%). On the other hand, hen selection depends on mothering ability (81.7%). Brooding seasons are from December to March (33.6%) and from March to June (31.9%). Prevention of broodiness in hens (88.7%) is performed by methods such as a bath or isolation (Table 6).

Constraints on Backyard Chicken Production

Feed shortages (36.5%), diseases (21.9%), and predators (13.5%) were identified as the major challenges for LC production (Figure 1), a situation which is aggravated by the lack of technical assistance services (83.9%).

Table 3. Production systems and housing conditions of local chickens.

Variables	Ecoregions				Overall mean (%)
	WNY (n = 29)	CPY (n = 153)	LHSY (n = 24)	WSGM (n = 54)	
Production systems					
Free range	3.5	9.1	37.5	29.6	19.9
Semi-confined	37.9	27.5	12.5	31.5	27.4
Confined	58.6	63.4	50.0	38.9	52.7
Material of the chicken coop					
Walls					
Wire mesh	82.1	70.5	26.7	59.0	59.6
Wood	7.2	20.9	73.4	20.5	30.5
Recycled material	10.7	8.6	-	20.5	9.9
Roof					
Tarred-cardboard sheet	32.1	35.3	6.7	5.1	19.8
Galvanized steel sheet	53.6	51.1	60.0	64.1	57.2
Recycled material	10.7	10.1	33.3	25.6	19.9
No roof	3.6	3.5	-	5.2	3.1
Floor					
Dirt floor	60.7	80.6	73.3	76.9	72.9
Concrete	17.9	19.4	26.7	7.7	17.9
Sand	21.4	-	-	15.4	9.2
Feeders					
Plastic/metal	27.6	33.4	12.5	35.2	27.2
Recycled containers	51.7	41.8	12.5	38.9	36.2
Dirt floor	20.7	24.8	75.0	25.9	36.6
Drinkers					
Plastic/metal	24.1	32.0	25.0	44.4	31.4
Recycled material	72.4	57.5	58.3	50.0	59.5
Stone	3.5	10.5	16.7	5.6	9.1
Nest					
Cardboard box	10.4	22.2	37.5	57.4	31.9
Recycled containers	24.2	17.7	-	1.9	10.9
Stone caves	10.4	17.6	-	-	7.0
Dirt floor	55.0	42.5	62.5	40.7	50.2

-: not observed; %: percentage; WNY: wetlands of northern Yucatan; CPY: central plain of Yucatan; LHSY: low hills of southern Yucatan; WSGM: wetlands of the southern gulf of Mexico.

DISCUSSION

In most developing countries, rural poultry production plays a significant role in improving the nutritional status, income, food security and livelihood of many smallholders (Abubakar *et al.,* 2007). Farm size or total land owned per household observed in the present study is greater than the value (0.0834 hectares) reported by Flota-Bañuelos *et al.* (2016) in rural zones of Campeche, Mexico. In contrast, farm size (0.25 ha) reported in Calakmul, Campeche by Alayón-Gamboa & Gurri-García (2008) was 0.05 hectares lower than those observed in this research. The livestock

Table 4. Management and feeding of local chickens.

Variables	Ecoregions				Overall mean (%)
	WNY (n = 29)	CPY (n = 153)	LHSY (n = 24)	WSGM (n = 54)	
Family member					
Mother	79.3	83.0	70.8	72.2	76.3
Father	13.8	6.5	20.8	16.7	14.4
Children	3.5	9.2	8.4	11.1	8.1
Grandparents	3.4	1.3	-	-	1.2
Feeding schedule for flock					
At dawn	6.9	4.3	10.4	2.8	6.1
At dawn/sunset	31.0	38.9	35.5	37.1	35.6
at dawn/noon/sunset	62.1	56.8	54.1	60.1	58.3
Feeding of the chickens (> 4 weeks age)					
Chickens scavenge free range	17.2	17.0	54.2	14.8	25.8
Waste (kitchen or market)	13.8	7.9	4.1	9.2	8.7
Corn (whole, broken or dough)	55.1	57.5	41.7	48.2	50.6
Commercial feed	3.6	7.7	-	27.8	9.8
Mixture of corn dough and wheat bran	10.3	9.9	-	-	5.1
Feeding of the chicks (0 to 4 weeks age)					
Chicks scavenge free range	3.5	5.9	-	5.6	3.7
Waste (kitchen or market)	3.4	2.6	4.2	5.5	3.9
Corn (whole, broken or dough)	17.3	15.0	-	11.2	10.9
Commercial feed	72.4	68.6	75.0	70.4	71.6
Mixture of corn dough and wheat bran	3.4	4.6	4.2	1.8	3.5
Rice	-	3.3	16.6	5.5	6.4
Type of supplement for chickens scavenge					
Corn (whole, dough or tortilla)	45.5	11.1	68.4	37.0	40.5
Commercial feed	-	33.3	-	25.9	14.8
Mixture of corn dough and wheat bran	27.2	51.9	26.3	29.6	33.7
Rice	27.3	3.7	5.3	7.5	11.0
Complementary reason					
Increased production (meat or eggs)	41.2	41.7	20.0	52.5	38.9
Faster growth	35.3	39.0	65.0	27.5	24.4
Improve health	23.5	19.3	15.0	20.0	36.7
Type of water provided					
Well-water	27.6	12.4	33.3	35.2	27.1
Drinking water	72.4	87.6	66.7	64.8	72.9

-: not observed; %: percentage; WNY: wetlands of northern Yucatan; CPY: central plain of Yucatan; LHSY: low hills of southern Yucatan; WSGM: wetlands of the southern gulf of Mexico.

species present in the backyards found in this study are in line with those found by Candelaria-Martínez *et al.* (2016), who pointed out that chickens (70.7%) and turkeys (16.4%) were the main animal species in the backyards of Campeche State. These authors, as in the case of the present study, report that poultry provides a source of food and cash income for rural farmers. Similar results about the use of poultry were found by Okeno *et al.* (2012) and Alemayehu *et al.* (2015) in backyards of developing countries such as Kenya and Ethiopia, respectively.

Table 5. Sanitary management of local chickens.

Variables	Ecoregions				Overall mean (%)
	WNY (n = 29)	CPY (n =153)	LHSY (n = 24)	WSGM (n = 54)	
Cleaning of chicken coops (times per week)					
Zero	6.9	13.2	50.0	29.6	24.9
One	58.6	56.9	25.0	13.0	38.4
Two	27.6	18.8	16.7	20.4	20.9
Three	6.9	9.0	4.2	13.0	8.3
Seven	-	2.1	4.1	24.0	7.5
Vaccination					
Yes	34.5	27.0	33.3	27.8	30.7
No	65.5	73.0	66.7	72.2	69.3
Internal and/or external parasite control					
Yes	57.9	52.9	74.0	62	61.7
No	42.1	47.1	26.0	38	38.3
Predisposing factors for diseases					
Birds within and among flocks	13.8	14.0	25.0	13.2	16.5
Rainy season	31.0	56.7	41.7	45.3	43.7
Unknown	55.2	29.3	33.3	41.5	39.8
Favourable season for diseases					
March to June	32.1	37.3	33.3	35.3	34.5
June to September	28.6	44.7	50.0	52.9	44.1
September to December	14.3	12.7	12.5	9.8	12.3
December to March	25.0	5.3	4.2	2.0	9.1
Observed diseases					
Flu and diarrea	25.0	65.9	87.5	93.3	46.9
Bird pox	75.0	34.1	12.5	6.7	32.1
Diseases control					
Home remedies	46.4	43.4	12.5	29.6	33.0
Drugs	39.3	40.8	70.8	51.9	50.7
Sacrifice	3.6	4.6	4.2	3.6	4.0
Consult veterinarian	3.6	4.0	8.3	1.9	4.4
Nothing	7.1	7.2	4.2	13.0	7.9
Birds susceptible					
Cocks/hens	10.7	12.5	33.3	21.6	19.5
Pullets/cockerels	21.4	16.5	-	13.7	12.9
Chicks	57.1	49.3	41.7	43.1	47.8
All	10.8	21.7	25.0	21.6	19.8

-: not observed; n: sample size; %: percentage; WNY: wetlands of northern Yucatan; CPY: central plain of Yucatan; LHSY: low hills of southern Yucatan; WSGM: wetlands of the southern gulf of Mexico.

The flock size found in this research fall within the range reported in backyards in rural areas of Campeche by Candelaria-Martínez *et al.* (2016) and Flota-Bañuelos *et al.* (2016), who found 20.7 and 24.1 chickens per flock, respectively. In addition, Okeno *et al.* (2012) observed a flock size of 22.4 birds in backyards of Kenya, but flock structure was different to the findings of the present research. According to the farmers, the higher number of hens in the flock is due to their objective to increase both egg and chick production. The number of clutches reported in this study was

Table 6. Breeding method and selection criteria of local chickens.

Variables	Ecoregions				Overall mean (%)
	WNY (n=29)	CPY (n=153)	LHSY (n=24)	WSGM (n=54)	
Breeding practice					
Yes	17.2	11.1	20.8	16.7	16.5
No	82.8	88.9	79.2	83.3	83.5
Breeding methods					
Acquiring improved breeds	13.8	13.1	20.8	16.7	16.1
Selecting local chickens	86.2	86.9	79.2	83.3	83.9
Selection criteria for acquiring					
Cock					
Plumage colour and comb type	50.0	30.0	-	-	20.0
Body size	50.0	55.0	80.0	100.0	71.2
Age	-	15.0	20.0	-	8.8
Hen					
Plumage colour and comb type	25.0	25.0	-	-	12.5
Body size	25.0	45.0	75.0	80.0	56.2
Number of eggs	-	10.0	25.0	10.0	11.3
Mothering ability	50.0	20.0	-	10.0	20.0
Selection criteria for breeders within flock					
Cock					
Plumage colour and comb type	57.1	32.6	26.1	13.2	32.2
Body size	32.1	56.3	65.2	77.4	57.7
Resistance to diseases	3.6	4.2	-	1.9	2.4
Meat yield	-	5.6	-	1.9	1.8
Paternal fertility	7.2	1.3	8.7	5.6	5.7
Hen					
Plumage colour and comb type	13.9	6.2	8.3	5.7	8.5
Body size	24.1	44.5	29.2	60.4	39.5
Resistance to diseases	-	2.1	4.1	3.7	2.5
Number of eggs	24.1	21.9	4.2	11.3	15.4
Mothering ability	37.9	25.3	54.2	18.9	34.1
Selection of egg for hatching					
Large size	40.9	64.4	44.4	47.2	49.2
Freshness	59.1	30.0	55.6	41.7	46.6
Most productive chickens	-	5.6	-	11.1	4.2
Selection of hen for hatching					
Body size	-	20.4	31.6	21.2	18.3
Mothering ability	100.0	79.6	68.4	78.8	81.7
Favorable season for incubation					
March to June	20.7	43.5	20.8	42.6	31.9
June to September	20.7	24.5	33.3	31.4	25.7
September to December	3.4	6.8	8.4	9.3	8.8
December to March	55.2	25.2	37.5	16.7	33.6
Prevent broody hens					
Yes	78.6	96.7	100.0	79.6	88.7
No	21.4	3.3	-	20.4	11.3

-: not observed; %: percentage; WNY: wetlands of northern Yucatan; CPY: central plain of Yucatan; LHSY: low hills of southern Yucatan; WSGM: wetlands of the southern gulf of Mexico.

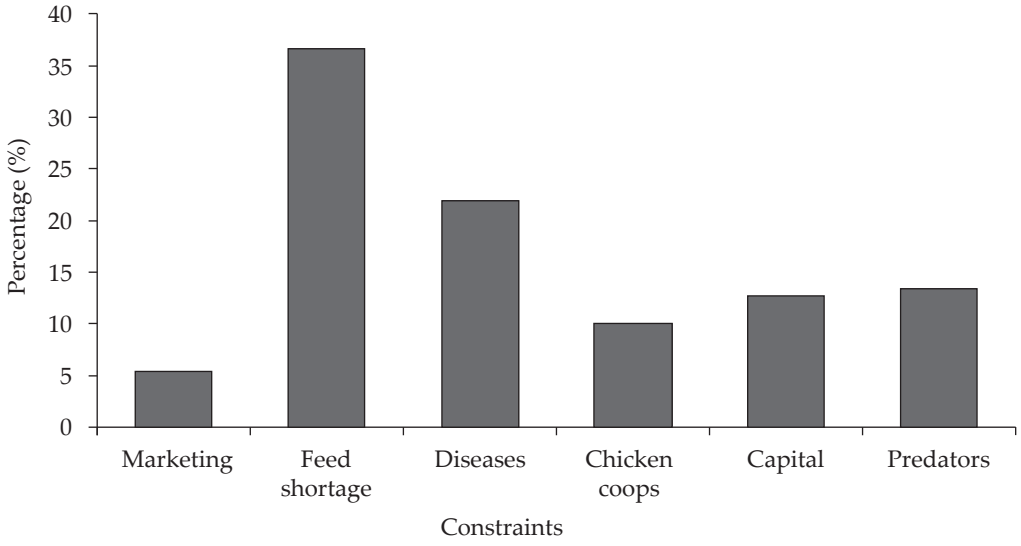

Figure 1. Constraints of local chicken backyard production.

not in line with findings reported by Centeno-Bautista *et al*. (2007), who recorded 2.3 clutches per year. On the other hand, hatchability percentage of eggs in this study was higher than the values (61.3%) mentioned by Juárez-Caratachea & Ortiz-Alvarado (2001) and Gutiérrez-Triay *et al*. (2007), whereas the age at sexual maturity of the chickens is similar to that found by Juárez-Caratachea & Ochoa (1995).

Farmers raised birds in confined and semi-confined systems and have well built chicken coops. According to the farmers, LC are kept confined because of the financial support they received from the Mexican government for the construction of chicken coops (SAGARPA, 2016). In line with our results, Camacho-Escobar *et al*. (2011) in Oaxaca, Mexico and in other developing countries (Abdelqader *et al*., 2007) observed that the chicken coops were equipped with feeders and drinkers made with recycled kitchen containers and the hens lays their eggs on the dirt floor or in cardboard boxes; the use of locally available materials reduces input costs. On the other hand, farmers that did not have chicken coops (15.4%) mentioned that a lack of money (67.5%) is the main constraint for their construction; therefore, they practice the free-range system.

Regarding the management and feeding of LC, the parents take care of the birds, they feed them three times a day. Similarly, Cuca-García *et al.* (2015) reported that LC are mainly cared for by housewives, children and senior citizens. Regarding feeding frequency, results of this study are in contrast with those reported by Camacho-Escobar *et al.* (2011), who found that the rural people of Oaxaca and Puebla, Mexico, fed their chicks from five to six times a day. In addition, Atehortua *et al.* (2015) observed in Colombia that a group of surveyed families fed their hens once a day. Flock feeding practices agree with those found by Candelaria-Martínez *et al.* (2016), who mentioned that the main feedstuff for birds was corn (91.0%). Although the inclusion of local feedstuffs such as mucuna beans (*Mucuna pruriens* L.), chaya (*Cnidoscolus aconitifolius*) leaf meal, and tropical tree legume (*Leucaeca leucocephala*) for poultry feeding has been reported (Sarmiento-Franco *et*

al., 2002; Trejo *et al.,* 2004; Flores & Bautista, 2012), the use of alternative local feedstuffs in Campeche, Mexico is rare. This could be attributed to the fact that rural people are unaware of the nutritional value of these feed sources. Local chickens in a free-range system depend on field grains, insects, earthworms, green matter, crop residues, homestead pickings and kitchen waste for their feeding as reported by Bhuiyan *et al.* (2005). This is why farmers supplement scavenging chickens with corn and wheat bran, in order to improve production and health mainly. In contrast, Addisu *et al*. (2013) indicate that in Ethiopia chickens are supplemented to increase growth, meat yield and egg production.

The cleaning frequency of the chicken coops was similar to that reported by Addisu *et al*. (2013) in northern Ethiopia, who found that farmers cleaned their chicken coops at least once a week. In addition, the lack of vaccination programs found in this study coincides with the reports of Centeno-Bautista *et al*. (2007) in other regions of Mexico. On the other hand, the season with the highest incidence of diseases is similar to that reported by Yemane *et al*. (2013) in Ethiopia. These authors found that the severity of the diseases was higher during the rainy season (75.4%) than in the dry season (24.6%). They also found that disease treatment is based on home remedies involving the use of tabaco leaves (*Nicotiana tabacum*), lemon juice (*Citrus limon*) and cooking oil, which is similar to the findings in the present study. Additionally, chicken diseases found in this research is in line with those reported by Centeno-Bautista *et al*. (2007) and Candelaria-Martínez *et al*. (2016) in the central-south region of Mexico.

Breeding practices implemented by the farmers in this research is in line with that reported by Addisu *et al*. (2013), who observed that indigenous chicken production system was characterized by lack of breeding practice in Amhara Region, Ethiopia. Moreover, selection criteria identified in this study are similar to those found in other backyard poultry production systems (BW, feather color and egg production) in other developing countries (Zewdu *et al*., 2013). Selection practices prior to incubation mentioned by farmers agree with those reported by Addisu *et al*. (2013), where egg selection is based on size and whether they come from productive chickens. Findings of the present study suggest that farmers improve the flock´s productivity using their experience. They select eggs and broody hens with the best production features because these traits will determine the production potential of the new flock. In addition, most farmers prefer mating among LC due to their advantage of being well adapted to local environmental conditions compared to improved genotypes.

In a study conducted in the rural communities of Puebla, Mexico, Centeno-Bautista *et al*. (2007) found that the main limitations on chicken production were predators, diseases, and a lack of technical assistance; these results agree with this investigation. Similarly, Addisu *et al*. (2013) reported that diseases (60.13%), feed shortages (20.59%), and predators or theft (19.28%) were the main constraints on backyard chicken production in North Wollo, Ethiopia. The lack of technical assistance observed in this research is consistent with findings in other developing countries; for example, Okeno *et al*. (2012) reported that in Kenya only a few farmers had extension services from government officers, but they were not frequently available and did not offer extension services targeting indigenous chicken production. Results of this study suggest that extension services are necessary to improve the management, housing conditions, feeding, breeding, and health of LC. It

thus appears that increased and better LC production may contribute to food security and poverty reduction of rural people in Campeche State, Mexico.

CONCLUSION

The local chickens play a significant role in the household livelihood security of the rural people of Campeche State, Mexico because chickens are a source of animal protein and cash income. In addition, LC have the advantage of being well adapted to local environmental conditions, which make them an important genetic resource that can be more efficiently used. Factors such as inadequate nutrition, diseases, predators and a lack of technical assistance services were the major challenges for LC production. Additionally, the characterizing the backyard poultry production system is a necessary step in the development of a program for the utilization of local poultry genetic resources under the natural environmental conditions of Campeche State, Mexico, because it helps to identify objectives and selection criteria, and establish the scope of the program.

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