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The Ri chicken breed and livelihoods in North Vietnam: characterisation and prospects

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Abstract

For the last twenty years, the consumption of poultry meat has boomed in Vietnam as in the rest of the developing world. Capital-intensive production has grown rapidly to satisfy this demand. Based on a few numbers of genetically uniform strains, these systems threaten biodiversity. In Vietnam, both rural and urban households still keep indigenous chickens as part of a diversified livelihood portfolio. In line with the national *in situ* conservation strategy, this study approached the context of local poultry keeping in two rural and one suburban districts of Northern Vietnam. It aimed at understanding households' willingness, constraints and opportunities for practice improvement, including breeds' management. As the Ri chicken constitutes the large majority of backyard flocks, two particular objectives of this study are the morpho-biometric characterisation of phenotypic diversity among individuals classified as Ri by farmers and an assessment of their productive potential. Chicken was found to hold a different place in livelihoods of the three districts with consequences on the management of genetic resources. The most favourable conditions for improvement of the Ri breed was found in the rural district of Luong-Son, due to market integration. In the more remote district of Ky-Son, living standards were lower and much would be gained from Ri conservation. Ri breed was the most threatened in the suburban Gia-Lam district, where poultry was a minor side-activity, lacking incentive for genetic management. From motives and constraints, tracks about breeding goals are suggested. Further considerations about conservation, improvement, market integration and livelihoods are proposed.

Keywords: biodiversity, chicken, Ri, Vietnam, breeding

1 Introduction

For the last forty years, the consumption of animal products has dramatically increased in the developing world, spurred by urbanisation and income rise (Delgado *et al.*, 1999). Termed Livestock Revolution, this phenomenon is more properly to conceive as primarily east Asian, driven by the tremendous economic development of China. Nevertheless, a truly global revolution occurred indeed, the consumption of poultry meat having boomed across almost every region of the developing world (FAOSTAT, 2010). Part of this ravenous demand has been satisfied by the mushrooming of large-scale capital-intensive poultry farms, based on the exploitation of a handful of highly productive strains. By leaking out of those breeding units and by leading households to cease family production, this flow of uniform genetics puts pressure on local genetic resources, explaining the greater erosion of biodiversity in poultry compared to other livestock species (FAO, 2007).

In South-East Asia, which is a second hub of Livestock Revolution after China, Vietnam experienced a rapid economic growth over the last decade (over 8% yearly GDP growth before 2008 crisis) and a strong de-

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cline of poverty (from 37.4% to 14.5% between 1998 and 2008) (General Statistics Office, 2009). At this stage of a rapid development, it may be considered crucial for the country to question the contribution of its different animal production systems to the satisfaction of a growing demand for milk, meat and eggs as well as considerations for rural development and biodiversity.

The share and role of poultry in livelihoods of Vietnamese households are highly variable. Some of the relevant classifying factors are the total income level, the raising system, and urban vs. rural location (Maltsoglou & Rapsomanikis, 2005). A clear regional cleavage moreover appears, people from Northern mountainous regions getting a wider share of their income from poultry and more generally from livestock (Epprecht, 2005). Ranking second after pigs, poultry's contribution to households' total income ranges from 0 to 50% in extensive systems; with almost half of the distribution under 10% (Maltsoglou & Rapsomanikis, 2005; Burgos *et al.*, 2008). The share of households keeping backyard poultry varies between regions. Estimations for this share range from 70% to 90% in the North while the national mean is around 50% (Maltsoglou & Rapsomanikis, 2005; Hong Hanh *et al.*, 2007; Desvaux & Tôn, 2008). In Vietnam as in many developing countries in Asia or Africa, backyard poultry owes its wide diffusion to both its socio-cultural and economic importance (Kitalyi, 1998; Dolberg, 2003). Chicken are indeed slaughtered or exchanged at several social or religious events, being thus involved in the maintenance of cohesion in a community. On the economic side, backyard poultry keeping appears as a low-input strategy for ensuring household's access to animal protein or as a form of saving, risk management or agricultural input. This role in livelihoods and social inclusion is crucial to the poorest or the most vulnerable members of a community. As such, women are often in charge of poultry keeping in a household. Therefore poultry keeping support is considered as a key in poverty alleviation strategies, particularly in relation with gender issues (Mack *et al.*, 2005; Gueye, 2005).

In the recent years, avian influenza outbreaks in Vietnam induced strong governmental control measures which proved often detrimental to family poultry keeping, as its extensive system was perceived as a health hazard (Hong Hanh *et al.*, 2007). This biased control policy appears as an additional threat to livelihoods of the rural poor as well as to biodiversity. However, since Vietnam Domestic Animal Conservation Project started in 1989, many governmental decisions came in support of farm animal biodiversity (Vang, 2003). In this regard, the central role of cultural diversity in the conservation of biodiversity has been acknowledged, with a special reference made to multi-ethnic Northern mountainous regions of Vietnam, in addition to the role of a market-driven conservation strategy, by the development of outlets for traditional breeds (Thuy *et al.*, 2003; Vang, 2003).

In 2003, indigenous breeds were estimated to represent over 80% of the total chicken flock of Vietnam (Vang, 2003). The following breeds were recorded: Ri, Te (or Lun, short leg), Tau Vang, Ac (black meat, white or black feather), Oke, H'mong, Tre, Choi (fighting chicken), Phu Luu Te, To, Dan Khao (six toes), Mia, Ho, Dong Tao (thick legs) and Van Phu (Vang, 2003; Eaton *et al.*, 2006). The Mia, Ho and Dong Tao breeds are reported as endangered or critical, while the Van Phu breed could have been lost during the last years (Vang, 2003; Tieu *et al.*, 2008). With a breeding flock of over 12 million individuals, the Ri breed represents 85% of the local chickens (Thuy & Vang, 2002; Eaton *et al.*, 2006). While the Ri chicken is mentioned as a well-defined yellow-feathered breed in the Atlas of Farm Animal Breeds in Vietnam (Su *et al.*, 2004), some authors rather consider this breed as a miscellany of indigenous chickens (Eaton *et al.*, 2006).

In line with the national in situ conservation strategy, the present study approaches the context of local poultry keeping in Northern Vietnam. It aims at understanding households' willingness, constraints and opportunities for practice improvement, including breeds' management. Because the Ri chicken constitutes the large majority of traditional flocks, acquiring further knowledge about this breed was a particular aim of this work. Phenotypic diversity inside the Ri breed was tackled through the morpho-biometric characterisation of individuals classified as Ri by farmers. Their productive potential under extensive and semi-intensive raising system was moreover assessed.

2 Materials and Methods

2.1 Study area

The study was conducted in June 2010 in three districts of North Vietnam. Two districts were selected in the mountainous Hoa-Binh province, namely Ky-Son (KS) and Luong-Son (LS), and one in the Hanoï province, Gia-Lam (GL). KS (210 km^2) is mainly part of the Ba-Vi mountain range. Economic activity is there based on forestry and agriculture. Located closer to Hanoï, LS (370 km^2) covers a lower part of Ba-Vi Mountains and thus consists of more plains. Accordingly, economy is there more diversified compared to KS: tourism, handcraft and industry are important sectors beside agriculture and forestry. Although the distance to Hanoï is less than 100 km, villagers from KS

and LS usually need 5 and 3 hours, respectively, to reach Hanoï on small motorbikes. GL (115 km^2) is part of the Hanoï suburbs and is known for its ceramics and medicinal herbs. Agriculture (rice, legumes, and aquaculture) is still present in the district. Many foreign and national enterprises as well as Hanoï University of Agriculture are established in GL.

2.2 Survey of households keeping backyard poultry

The interviews were semi-structured and covered household characteristics (members, activities, agricultural assets, and animal species kept), poultry keeping motives and practice (feeding, housing, culling/sale/consumption decision), poultry breeds (number, description, and preferences), and management of the Ri breed (breeding schemes, criteria, perceived evolution). Fifty-two households were included in the survey: 26 in KS, 15 in LS and 11 in GL.

2.3 Ri breed characterisation

2.3.1 Morpho-biometric characterisation

Adult animals were exclusively used for morpho-biometric characterisation (173 females and 50 males over 10 month of age). The different body measurements were recorded in accordance with the FAO recommendations (1981), by means of a digital balance (1g accuracy), an electronic sliding calliper (0.01mm accuracy) and a tape measure. The following parameters were studied: sex, body weight, reported age of the animal, thoracic girth, feathers type and colour, the comb's type, length, height and colour, wattles' height and colour, tarsus length and diameter, wings' length as well as the length and colour of the beak. The animals that were used in this study belonged to the enquired households as well as to the Livestock Research and Training Centre in Hanoï (RC).

2.3.2 Growth performance under semi-intensive conditions

The chicks (n=71) were floor-bred on a sawdust litter in a ventilated building (no air conditioning). Chicks were first put under a heating lamp and the room temperature was regulated manually according to chicks' behaviour. Continuous light regimen was adopted for the whole experiment period. Animals were fed ad libitum with a starter mix until the age of eight weeks (2800 kcal ME/kg, 18% crude protein) and then passed to a broiler mix (2700 kcal ME/kg, 15% crude protein) that was given ad libitum until 19 weeks of age. Both mixes contained wheat, corn, soy, soybean cake, methionine, lysine, vitamins and BHT ethoxyquins antioxidant. Sexing was achieved visually in the fourth week. A total of 30 males and 30 females were weighed weekly (at fixed day and hour) from hatching until 19 weeks.

2.3.3 Egg quality assessment

Ninety eggs were freshly collected from laying hens of 40 and 60 weeks of age (50 and 40 eggs, respectively) from the RC. Egg measurements, constituents (proportions, pH, Haugh's Units) and eggshell resistance were assessed through a standard evaluation procedure as described in Moula *et al.* (2010). Colours of eggshell and yolk were evaluated on the scoring scales. Scores for eggshell colour ranked from 1 (white) to 5 (dark brown). The 15-levels Roche scale was applied to yolk colour, a score of 1 indicating light yellow and 15 deep orange.

2.4 Data analysis

All statistical analyses were performed with the SAS software (SAS Institute, 2000).

2.4.1 Socio-economic and morpho-biometric surveys

Descriptive statistics were calculated for all socio-economic and morpho-biometric parameters. Comparisons between districts were performed with Chi-square or exact Fisher's tests for citation rates and qualitative morpho-biometric data, ANOVA for quantitative socio-economic or morpho-biometric data (generalised linear model, proc glm) and Kruskal-Wallis test for animal numbers kept by households. For quantitative morpho-biometric traits, the fixed linear model studied was the following: $Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + e_{ijk}$, with Y= trait, μ= mean, A_i= fixed effect of districts (i= 1, 2, 3, 4; for RC, GL, KS, LS), B_j= fixed effect of sex (j= 1, 2; for male and female), $(AB)_{ij}$= effect of interaction between sex and district, e_{ijk}= residual random effect.

2.4.2 Growth performance

Growth curve parameters were estimated, according to the following Gompertz equation: $y = \alpha \times exp(-\beta \times exp(-\gamma \times t))$, where y = weight of broiler (in grams); α= asymptotic weight (in grams); β = integrating constant; γ= growth speed factor (maturation factor) and t is the time (Porter *et al.*, 2010). These parameters were estimated through a non-linear regression procedure using the Marquardt method (Proc nlin). The age to inflexion (T_i), corresponding to the period when growth is maximum, is calculated using the following formula: $T_i = (1/\gamma) \times ln\beta$ (Porter *et al.*, 2010).

2.4.3 Egg quality assessment

Eggshell colour proportions were compared between districts by the Chi-square test. The effect of age on each parameter was tested through mean comparison (Student-test).

3 Results

3.1 Household survey

3.1.1 Household characteristics and agricultural activities

Part of these results are presented in Table 1. Respondents were mainly men. Only three women (in GL) could be interviewed. Two different ethnic groups were found, the Kinh and the Muong. The latter group was the sole present in KS while both groups were present in GL and LS. In KS, agriculture was almost the sole occupation. Professions were more diversified in LS and GL, where shop and restaurant owners, civil servants or pensioners (two in GL) were met. Agriculture was still the main occupation of about 60% and 18% of households in LS and GL. Median age of respondents was 50 years, ranging from 27 to 77. Age distribution was uniform across districts ($p > 0.1$). The average household was composed of 5.8 members, varying from 2 to 10. Households were significantly larger in LS ($p < 0.05$). Only 11 households in LS have communicated estimation for yearly income. This income ranged from 3.2 to 6 million VND (153 to 288 USD; mean ~248 USD). Education level varied across districts ($p < 0.05$). Schooling duration was significantly longer in LS compared to GL and KS ($p < 0.05$).

Almost 90% of households combined cropping, forestry and livestock activities in KS, as half of households in LS and none in GL. In the latter district, 73% of households combined cropping and livestock, as in 40% of households in LS. Livestock keeping was the only agricultural activity in only five households (two in GL and three in LS, 27% and 13% respectively). Land plot areas did not differ between districts ($p > 0.1$) and varied between 0.247 and 1.616 acre (median 0.741).

Besides poultry, livestock species were diversified (Table 1). The median number of chickens (adult and young) per household across districts was 57 (ranging from 19 to 264). Largest flocks were found in LS (median 165) followed by GL (median 69) and KS (median 44.5) ($p < 0.05$). Chicks and immature chickens represented about 81% of the flocks. The young-to-hen ratio differed significantly between districts, values of 9.5 ± 4.9, 4.5 ± 3.1 and 7.1 ± 2.0 being calculated in KS, LS and GL, respectively ($p < 0.05$). Hen to male ratios in the three districts were 5.3 ± 4.2, 8.2 ± 3.6 and 6.6 ± 3.5, respectively ($p > 0.05$). Pigs were kept by 67% of households, with higher mean number per household in LS ($p < 0.05$). Water buffaloes were also widespread, being owned for draft purpose by half of households. Again, the mean number by household was highest in LS ($p < 0.05$). Dogs were raised for home consumption in all districts, with numbers varying from 1 to 15 dogs per household. Cattle were also found in the three districts but only in six households. Milk production was reported by interviewees in KS and GL but not in LS. Ducks were kept in GL and LS. As also shown in Table 1, the origin of poultry flocks differed between districts ($p < 0.05$). Flocks origin was mostly inheritance in rural districts while purchase dominated in GL ($p < 0.05$).

Table 1: *Socio-economic characteristics of households holding Ri chicken in two rural (KS and LS) and one suburban (GL) districts of North Vietnam.*

Category	*n*	*KS*	*LS*	*GL*
Main activity (%)				
Agriculture	36	96.1	60.0	18.2
Non-agriculture	16	3.8	40.0	81.8
Ethnic group (%)				
Muong	36	100	60.0	16.7
Kinh	10	0.0	40.0	83.3
Education (%)				
University degree	7	3.8	40.0	0.0
6–10 years	22	34.6	46.7	54.5
1–5 years	23	61.6	13.3	45.4
Household size (n)	52	5.5 ± 0.4	7.1 ± 0.5	4.6 ± 0.5
Land area (are)	52	29.6 ± 2.9	30.4 ± 3.4	25.4 ± 3.8
Livestock [1]				
Chicken	52	55.5 ± 35.2	147.1 ± 82.4	96.0 ± 69.4
Duck	7	–	12.7 ± 8.1	10.0 ± 3.6
Pig	33	6.1 ± 4.8	16.6 ± 12.5	9.2 ± 5.8
Cattle	6	9.3 ± 8.4	7.0 ± 0.0	8.0 ± 1.4
Water buffalo	26	4.4 ± 2.4	12.6 ± 12.2	3.3 ± 1.5
Dog	10	10.0 ± 0.0	9.0 ± 3.5	5.7 ± 4.2
Flock origin (%)				
Inheritance	35	76.9	93.3	9.1
Purchase	13	15.4	0.0	81.8
Gift	4	7.7	6.7	9.1

[1] mean stock ± standard deviation (number of households holding a particular species); (n): number of households;
KS: Ky-Son; LS: Luong Son; GL: Gia-Lam

3.1.2 Poultry breeds

Besides Ri, two chicken breeds were present in all districts: Hmong and Choi. Hmong is a black-feathered chicken, the meat of which is also pigmented. Choi is a typical fighting chicken. The Mia breed, described by

respondents as "similar to the Ri with a larger size", was also found in GL and LS. Ri accounted for about 90%, Choi and Hmong for fewer than 5% and Mia under 2% of total flock.

3.1.3 Poultry keeping practices and constraints

Data for this topic are gathered in Table 2. In GL and KS, all the family members were involved in poultry keeping duties in over 90% of households. Women were the only members to perform poultry-related tasks in the rest of households in both districts. The situation was more diverse in LS, where all configurations were found. In almost all households, chickens were freely scavenging and were kept in a small closed shelter for nighttime. In only three households in GL, chickens were reared fulltime in medium-sized hangar made of bricks, cement and tinplate (households keeping 8, 16 and 34 hens). In LS and KS, all the night shelters were built with bamboo. Cement and tinplate could also be used in KS and LS but less frequently than in GL, according to their availability. Straw was often used in KS but not in LS.

The basis for poultry feeding was rice (cooked grains, meal or bran) in all cases. Maize and cassava were commonly used in all districts. Aquatic plants (*Azolla* spp., (*Ipomoea aquatica*) were also fed to chicken in most cases in KS, in half of households in GL and in some of LS ($p < 0.001$). Kitchen residues were often given to chickens in KS and GL but less in LS ($p < 0.001$). Health management through modern medication (antibiotics, antiparasitic, vaccine) was very common in the rural district of KS while only a third of households in LS reported such usage and none in suburban district of GL ($p < 0.001$).

Closed flocks, defined as a lack of introduction of new animals from outside the village since at least five years, were more common in KS than in LS; while all flocks were open to entries and exits of chicken through commercial exchange in the suburban GL ($p < 0.05$). About possible crossbreeding between local poultry breeds present on the village, all interviewees in GL and a majority of them in KS believed that such crosses did occur, none declaring any practice of controlled mating. The reverse was asserted by 80% of respondents in LS, who also stated some control of mating ($p < 0.001$). Among the other 20% of LS households, breeding could be controlled or not. In accordance with these statements, poultry keepers in LS that denied the existence of crossbreeding did not observe any modification in the phenotype of their Ri chickens. Such changes were reported in GL and KS ($p < 0.001$). Regarding the choice of breeding males, half of the interviewees declared considering size and general conformation as criteria in all districts ($p > 0.1$). Weight was chosen as a selection criterion in LS and GL but almost not in KS ($p < 0.01$). Plumage was an important criterion on its own in GL ($p < 0.01$) while in LS and KS, breeders took into account the animal aspect in a more general way, including plumage but also head and tarsus aspect ($p < 0.05$).

Table 2: *Poultry keeping practices among households breeding Ri chicken in two rural (KS and LS) and one suburban (GL) districts of North Vietnam (Citation rate in %).*

	KS	*LS*	*GL*
Family member involved			
All the family	96.2	40.0	90.9
Women only	3.9	20.0	9.1
Men only	0.0	26.7	0.0
Children only	0.0	13.3	0.0
Shelter material			
Bamboo	100	100	63.6
Straw	76.9	6.7	45.5
Cement	11.5	66.7	72.7
Wood	7.7	13.3	18.2
Metal sheet	7.7	0.0	45.5
Feed sources			
Rice	100	100	100
Maize	65.4	93.3	90.9
Aquatic plants	84.6	13.3	54.5
Cassava	92.3	73.3	72.7
Kitchen residue	88.5	26.7	72.7
Medication			
Regular	92.3	33.3	0.0
Genetic management			
Control of mating	0.0	93.3	0.0
Closed flock management	57.7	26.7	0.0
Cross-breeding denied	23.1	80.0	0.0
Report of changes in Ri [1]	69.2	20.0	100
Selection criteria (male)			
Weight	7.7	46.7	54.6
Size, conformation	53.9	46.7	54.6
Plumage	7.7	0.0	63.6
Phenotype [2]	53.9	20.0	0.0
Stated constraints			
No complaint	46.2	13.3	0.0
Insufficient laying	53.9	86.7	100
Insufficient growth	34.6	86.7	45.5
Diseases	3.9	86.7	0.0
Predation	38.5	46.7	18.2

[1] plumage, tarsus, comb, eggs, growth;
[2] plumage, head, tarsus aspect

While almost all households expressed complaints in GL and LS, about half of them in KS did not find any suggested constraints relevant to their situation. All complaining households in LS cited insufficient laying and growth as well as diseases, while predation due to foxes, weasels and snakes was cited by half of them. In GL and KS, insufficient laying and growth were mostly cited along with predation but diseases were almost not cited.

3.1.4 *Motives for poultry keeping and breed preference*

Motives for production, use of poultry products and preference for the Ri breed are presented in Table 3. Meat was cited as being the main poultry product of interest by almost all interviewees in all districts. Egg production appeared as a motive more often in LS than in KS and GL ($p < 0.001$). Two poultry keepers did not mention either meat or egg as aims of this side activity. The concept of food security was a common motive in all districts ($p > 0.1$). Home consumption of meat was the main use of poultry in all districts. Almost all households also reported sale for meat consumption. Sale as breeder hen or cock was most frequent in LS ($p < 0.001$). Home consumption of eggs was not reported at all in GL but well by almost all households in LS ($p < 0.001$); an intermediate case was found in KS. A similar picture was given about egg sale for consumption, these being absent in GL, generalised in LS but almost absent in KS ($p < 0.001$). Egg sale for flock constitution was only noticeable in LS ($p < 0.01$). In all households, eggs were primarily considered for flock replacement needs.

The characteristics that were put forward by interviewees to explain their preference for the Ri breed are detailed in Table 3. Globally, the main reasons were linked to resilience and low needs for care. Price premium for products and meat flavour were often cited as well. Some variation between districts can be observed, such as the lesser importance of the resilience-linked justifications in GL ($p < 0.05$) and the particularly strong consensus about breed qualities in LS. Egg laying performance and beauty were not acknowledged as important reasons for keeping the Ri breed. About perceived temperament of the Ri chicken, among the three terms 'wild', 'calm' or 'tamed', about 80% of interviewees in KS and GL chose 'wild' while 60% of respondents in LS chose 'tamed' and 'calm' (the remaining 40% not being able to choose) ($p < 0.001$).

Table 3: *Motives for poultry keeping and Ri breed preference among households in two rural (KS and LS) and one suburban (GL) districts of North Vietnam (Citation rate in %).*

	KS	*LS*	*GL*
Objective of poultry keeping			
Meat production	96.2	100	90.9
Tradition	88.5	73.3	72.7
Food security	73.1	86.7	54.6
Egg production	19.2	40.0	9.1
Birds use			
Home consumption	100	86.7	100
Sale for reproduction	15.4	73.3	36.4
Sale for consumption	92.3	100	90.9
Eggs use			
Home consumption	38.5	93.3	0.0
Stock maintenance	100	100	100
Sale for reproduction	3.9	40.0	0.0
Sale for consumption	3.9	100	0.0
Preference motives for Ri			
Adaptation	96.2	100	63.6
Resilience	92.3	86.7	81.9
Maternal behaviour	92.3	100	54.6
Low investment needed	92.3	100	45.5
Price premium	80.8	100	63.6
Open air rearing	92.3	100	27.3
Precocity	65.4	100	45.5
Rearing ease	73.1	100	54.6
Taste of meat or eggs	42.3	100	72.7
Laying performance	15.4	0.0	0.0
Longevity	11.5	0.0	36.4
Beauty	7.7	0.0	18.2
Breed conservation	3.9	0.0	0.0

3.1.5 *Reproductive performance*

Reported age at first egg was 4 to 6 months and hens were kept for 3 to 5 years before culling (similar age for breeding males). Reported yearly egg numbers were remarkably similar between households within districts, with values around 65 eggs in KS and GL and 100 in LS. Observed eggs number by brood ranged from 10 to 15 (median 12) and stated annual broods number varied from 2 to 4. Age at slaughter varied generally from 6 to 8 month (~72% of answers). Earlier slaughter at 4 or 5 month was also mentioned (~28% of answers).

3.1.6 *Product prices*

The reported price for a chicken varied between 80000 and 120000 VND/kg (3.89 to 5.84 USD/kg). Prices for eggs could be obtained in LS, where they varied between 2000 and 2500 VND per unit (0.10 to 0.12 USD per unit).

3.2 Morpho-biometric characterisation

3.2.1 Qualitative traits

Qualitative traits recorded on Ri individuals are presented in Table 4. Traits that were uniformly observed in all studied individuals are a smooth and normally distributed plumage, a yellow colour of skin and tarsus and a single comb. As a matter of fact, breeders did not point out as Ri chickens individuals that did not present the latter characteristics. In decreasing order of frequency, the four main plumage types were tan, golden salmon, wheat and dark red. Coppered black and silvered salmon were little observed. Plumage types repartitions were similar across districts ($p > 0.05$). Beaks were yellow or dark coloured, with different repartitions between districts for males ($p < 0.05$) but not for females ($p > 0.1$). The colour of the comb and the wattles was almost exclusively dark red in males and mainly red in females. Differences between districts for this feature were significant for females ($p < 0.05$). Both wattles and comb were almost exclusively red in females of LS and KS (95 to 100%), whereas light red was the only colour observed in RC and was more prevalent in GL (63%). Comb peaks number varied between 5 and 8 in males and between 4 and 8 in females. Combs with 6 peaks were more frequent in males (54%) and those with 5 peaks in females (53%).

3.2.2 Quantitative traits

Body weights and measurements recorded on Ri individuals are presented in Table 5. Mean body weights of adult males and females varied according to the district ($p < 0.001$). Heavier males were found in LS and at RC, slightly exceeding 2 kg, while weights in GL and KS approached 1.9 kg. Same difference could be found in females with heavier weights being recorded in LS and at RC (~1.5kg) and lighter weights in GL and KS (~1.35 kg). Statistically significant effect of district and sex could be found for all measured traits, except length of beak and thighs. A noticeable difference between districts is the smaller size (height and length) of comb and wattles for both sexes in KS. Moreover, Ri chickens in the latter district appeared as animals with comparatively longer backs and smaller breasts (length and circumference). Tarsus, which is described by breeder as thin in the Ri chicken, showed a mean circumference about 11 mm.

Table 4: *Qualitative morpho-biometric traits (colours) evaluated on male and female Ri chicken in four districts of North Vietnam (%).*

	sex	*colors*	*Total*
Number	M		50
	F		163
Beak	M	Dark horn	38.00
		Yellow	62.00
	F	Dark horn	28.22
		Yellow	71.78
Comb	M	Red	4.00
		Dark red	96.00
	F	Light red	33.13
		Red	66.87
Wattles	M	Red	4.00
		Dark red	96.00
	F	Light red	34.97
		Red	65.03
Feather	M	Tan	36.00
		Wheat	22.00
		Copper Black	6.00
		Gold salmon	32.00
		Siver salmon	4.00
	F	Tan	42.94
		Wheat	12.88
		Copper Black	4.29
		Dark red	9.82
		Gold salmon	22.70
		Siver salmon	7.36

RC: livestock research and training center of Hanoï; GL: Gia Lam; KS: Ky-Son; LS: Luong-Son; M: male; F: female

3.3 Growth performance

Mean weights of Ri chickens from hatching to 19 weeks are shown in Fig. 1. Mean weight at hatching was 27.96 ± 2.25 g. At week 12, weights of males and females were, respectively, 1047.14 ± 127.49 g and 837.67 ± 92.29 g. At week 19, these values were of 1838.42 ± 132.80 g and 1285.71 ± 145.31 g. Gompertz growth curve parameters differed between sexes. Asymptotic weight (α) of males was superior to that of females (2794.6 g vs. 1714.2 g, respectively) as well as the integrating constant β (4.419 vs. 4.160, respectively). Growth speed factor (maturation rate γ) was higher in females (0.148 vs. 0.129 in males) that reached their inflexion weight sooner, at 67.4 days vs. 80.6 days in males. Feed conversion index at week 19 was 6.36. Total mortality at the end of experiment was 15.5%.

Table 5: *Morpho-biometric traits measured on Ri chicken in four districts of North Vietnam (least square mean ± standard error).*

	Sex	Districts			
		KS	LS	GL	RC
Number	M	11	11	14	14
	F	47	51	35	30
Weight (g)	M	1872.73 ± 65.82^{b}	2080.91 ± 65.82^{a}	1993.57 ± 58.34^{ab}	2085.00 ± 58.34^{a}
	F	1369.68 ± 31.84^{b}	1503.53 ± 30.57^{a}	1327.71 ± 36.90^{b}	1475.33 ± 39.86^{a}
Beak Length (mm)	M	38.27 ± 1.32^{a}	38.20 ± 1.32^{a}	38.85 ± 1.17^{a}	36.65 ± 1.17^{a}
	F	30.54 ± 0.65^{b}	32.96 ± 0.61^{a}	32.54 ± 0.75^{a}	32.68 ± 0.80^{a}
Comb Length (mm)	M	62.05 ± 3.79^{b}	119.37 ± 3.79^{a}	111.47 ± 3.36^{a}	114.87 ± 3.36^{a}
	F	31.92 ± 1.84^{c}	42.76 ± 1.76^{d}	39.84 ± 2.13^{bd}	49.58 ± 2.30^{a}
Comb Height (mm)	M	48.44 ± 2.86^{b}	74.21 ± 2.86^{a}	70.82 ± 2.54^{a}	72.20 ± 2.54^{a}
	F	20.33 ± 1.39^{b}	28.11 ± 1.33^{a}	20.86 ± 1.61^{b}	27.42 ± 1.73^{a}
Wattles Height (mm)	M	41.05 ± 3.10^{c}	64.30 ± 3.10^{a}	56.05 ± 2.75^{b}	59.91 ± 2.75^{ab}
	F	18.10 ± 1.52^{b}	20.08 ± 1.44^{ab}	17.93 ± 1.76^{b}	24.66 ± 1.88^{a}
Tarsus Length (cm)	M	8.67 ± 0.23^{a}	9.14 ± 0.23^{a}	8.90 ± 0.20^{a}	9.10 ± 0.20^{a}
	F	6.89 ± 0.11^{b}	6.46 ± 0.10^{c}	6.91 ± 0.13^{b}	7.37 ± 0.14^{a}
Tarsus diam1 (mm)	M	15.25 ± 2.83^{a}	17.17 ± 2.83^{a}	16.30 ± 2.51^{a}	16.75 ± 2.51^{a}
	F	12.81 ± 1.39^{a}	13.02 ± 1.32^{a}	12.34 ± 1.59^{a}	12.74 ± 1.72^{a}
Tarsus diam2 (mm)	M	12.24 ± 0.35^{a}	13.72 ± 0.35^{b}	12.52 ± 0.31^{a}	13.06 ± 0.31^{ab}
	F	10.11 ± 0.17^{a}	10.48 ± 0.16^{b}	10.23 ± 0.19^{a}	9.95 ± 0.21^{a}
Neck Length (cm)	M	18.27 ± 0.41^{ab}	19.18 ± 0.40^{b}	17.85 ± 0.36^{a}	17.86 ± 0.36^{a}
	F	15.26 ± 0.20^{a}	15.04 ± 0.19^{ab}	14.66 ± 0.23^{b}	15.10 ± 0.25^{ab}
Back length (cm)	M	27.00 ± 0.78^{b}	26.45 ± 0.78^{b}	25.64 ± 0.69^{b}	23.43 ± 0.69^{a}
	F	20.94 ± 0.38^{bc}	21.75 ± 0.36^{c}	20.49 ± 0.44^{ab}	19.53 ± 0.47^{a}
Thigh length (cm)	M	16.18 ± 0.44^{a}	18.00 ± 0.44^{b}	17.28 ± 0.39^{ab}	16.64 ± 0.39^{a}
	F	13.09 ± 0.21^{b}	12.41 ± 0.20^{a}	13.17 ± 0.25^{b}	12.53 ± 0.26^{ab}
Keel length (cm)	M	13.00 ± 0.44^{c}	15.27 ± 0.44^{ab}	16.00 ± 0.39^{b}	14.86 ± 0.39^{a}
	F	10.28 ± 0.22^{c}	10.80 ± 0.21^{bc}	11.03 ± 0.25^{b}	12.40 ± 0.27^{a}
Thoracic circ (cm)	M	29.09 ± 0.67^{a}	31.73 ± 0.67^{b}	30.29 ± 0.60^{ab}	30.71 ± 0.60^{ab}
	F	24.30 ± 0.33^{b}	27.43 ± 0.31^{c}	25.48 ± 0.38^{a}	25.63 ± 0.41^{a}

RC: livestock research and training center of Hanoï; GL: Gia Lam; KS: Ky-Son; LS: Luong-Son; Dist: fixed effect of district; Sex: fixed effect of sex; Int: interaction between district and sex; diam1: diameter at widest part of tarsus; diam2: diameter at thinnest part of tarsus; Values followed by the same letter in the same row are statistically not significantly different ($p < 0.05$)

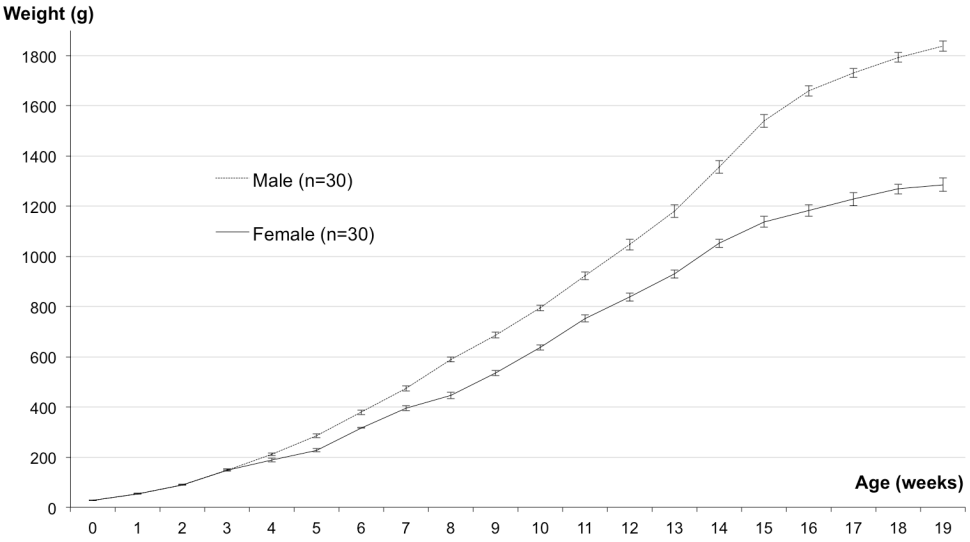

Fig. 1: *Growth curve for Ri chicken raised in experimental semi-intensive conditions*

Table 6: *Quantitative egg traits from 40- and 60-weeks old Ri chicken in North Vietnam.*

	Hen's age		*t-test*
	40 weeks	*60 weeks*	
Egg Weight (g)	38.78 ± 0.57	45.20 ± 0.61	***
Yolk weight (g)	12.31 ± 0.19	14.67 ± 0.21	***
Eggshell weight (g)	3.79 ± 0.08	4.59 ± 0.09	***
Albumen weight (g)	22.67 ± 0.44	26.04 ± 0.48	***
Albumen %	58.24 ± 0.45	57.43 ± 0.49	ns
Yolk %	31.84 ± 0.39	32.45 ± 0.43	ns
Eggshell %	9.79 ± 0.15	10.15 ± 0.16	ns
Y:A ratio (%)	55.47 ± 1.11	56.63 ± 1.21	ns
Yolk pH	5.91 ± 0.03	5.94 ± 0.04	ns
Albumen pH	8.90 ± 0.02	9.19 ± 0.02	***
Albumen height (mm)	5.87 ± 0.22	5.27 ± 0.24	ns
Haugh Units	81.62 ± 1.57	76.14 ± 1.71	ns
Yolk diameter (mm)	36.55 ± 0.32	38.13 ± 0.33	**
Egg length (mm)	48.85 ± 0.30	50.70 ± 0.33	***
Egg width (mm)	37.91 ± 0.17	39.76 ± 0.18	***
Shape index (%)	77.67 ± 0.47	78.56 ± 0.51	ns
Shell thickness ($\times 10^{-2}$ mm)	32.42 ± 0.45	26.56 ± 0.50	***
Max breakage force (N)	36.59 ± 0.81	37.88 ± 0.88	ns
Yolk color (score 1–15)	10.57 ± 0.14	10.08 ± 0.15	*

* $p < 0.05$; ** $p < 0.001$; *** $p < 0.0001$; ns: statistically not significant

3.4 Egg quality

Quantitative traits measured on eggs from 40-weeks and 60-weeks old hens are presented in Table 6. Hen's age had a statistically significant effect on absolute weights and dimension values ($p < 0.001$) but not on their ratios or proportions ($p > 0.1$). Albumen pH was also significantly affected by hen's age ($p < 0.001$), contrary to yolk pH and Haugh's units ($p > 0.1$). Mean egg weight was 38.8 ± 0.6 g at 40 weeks and 45.2 ± 0.6 g at 60 weeks. Albumen, yolk and eggshell accounted, respectively, for about 58%, 32% and 10% of egg weight. Yolk to albumen ratio was about 56%. While weight and dimension of the egg increased with the age of the hen, eggshell thickness was shown to decrease ($p < 0.05$). Nevertheless, maximal breakage force was not significantly affected by hen's age. Eggshell colour was mostly whitish (72% of eggs scored 3/5–4/5). Only 6% of them were truly white (score 1/5). Yolk colour was above 9/15 on Roche's scale for 90% of the eggs (orange to deep orange). This colour proved lighter for eggs from older hens ($p < 0.05$).

4 Discussion

4.1 Characteristics of the households keeping the Ri breed across districts

In line with the particular interest for the Ri chicken, the survey specifically targeted households keeping this breed. This choice accounts for the highly unequal numbers of households interviewed between districts. Therefore the unequal samples can be considered as a result, showing the wider distribution of the Ri breed among poultry keeping households in the most remote district, Ky Son (KS), followed by Luong Son (LS), which is still rural but lies closer to Hanoi, and the suburban Gia-Lam (GL) being last. Nevertheless, as Ri represents the majority of local poultry in Vietnam, besides an asymmetry in breed diffusion, this distribution also reflects that of backyard poultry or even of livestock in general, which is known to be especially high in Northern Mountains and lowest near urban centre (Epprecht, 2005). Another difference between districts lied in the ethnic groups composing the samples. Ethnic diversity

in North Vietnam is known to be particularly large, resulting in a wide cultural diversity, the role of which in biodiversity conservation is acknowledged by National Vietnam policies (Thuy *et al.*, 2003; Vang, 2003).

Diversity of occupations mirrored that of the global economic activity of the districts. The decreasing importance of agriculture in livelihoods across KS, LS and GL is in accordance with their respective distance to Hanoï. However, livelihood portfolios were diversified in all districts. Land plots were small, especially for rural households basing their subsistence on cultivation. The observed area is similar to the mean surface per household in Hoa Binh province, i.e. 1.031 acre (General Statistics Office, 2007). On basis of a proportion of home-consumption in total income of 40% (Maltsoglou & Rapsomanikis, 2005), the total annual income in LS can be estimated to 8.7 millions VND from survey data. This proves similar to the mean total income in rural areas (9.1 millions VND per year) (General Statistics Office, 2009). Despite the lack of data regarding GL and KS, it could be observed that living standards were clearly lower in KS compared to LS, while those in GL were similar to LS.

4.2 Poultry keeping practice and motives in rural and suburban districts

Housing and feeding of poultry appeared rather homogeneous across districts, with notable differences linked to locally available materials. The generalised provision of a night shelter could explain the low citation rate of predation among constraints. From the present results, the Ri chicken appears as generally kept in backyard extensive systems for home consumption of meat. In GL, which is close to the urban centre, neither semi-intensification nor market-orientation was observed. Paradoxically, veterinary care was most widespread in the remote KS, less so in LS and least in the suburban GL. This can be understood from the presence in KS of three veterinary doctors in a context where chickens are a crucial part of livelihoods. On the contrary, in GL, where veterinary services are also available, the lack of investment in veterinary care of chickens could result from the weak importance of the latter in the households' livelihoods. In LS, the situation is mixed and the relatively low use of veterinary care can be interpreted as a confirmation of the extensive nature of the chicken rearing system, despite a significant market orientation.

Mean chicken flock size was more than 2.5 times larger in LS than in KS. In the KS district, almost all households kept less than 19 adult chickens, which is the median number of chickens per household in Hoa Binh Province (General Statistics Office, 2007). Around 70% of flocks in LS were above that level. This confirms the comparatively lower endowment of households in the KS district. In GL, 60% of households had less than 17 adult chickens, which grossly corresponds to statistics for Hanoi (General Statistics Office, 2007). Although proximity to urban markets encourages the constitution of large flocks in suburbs, such larger flocks did not keep 'pure' Ri and were not included in the study.

These differences in flock structure are connected with important divergences in poultry keeping practice and motives. Commercialisation of live chicken was generalised across districts. However, motives in LS appeared globally more market-oriented. Indeed, in the latter district, eggs, hens and cocks for breeding were all commercialised. Strikingly, two households in LS did not declare any home consumption of poultry meat. When compared between LS and KS, the greater integration to markets of the former obviously relates to its closer proximity with Hanoi. Another major difference in motives was the greater attention paid to eggs as a poultry product in LS. The lower young-to-hen ratio in LS compared to KS might confirm this greater trend to egg consumption in LS. In KS, the small size of flocks could render egg consumption (or sale) unaffordable to households, as eggs are needed for reproduction and flock growth. In Gia-Lam, the absence of egg consumption or sale might refer to a restrictive acceptation of chicken keeping as a side activity for a population having access to a wider range of occupations in a cultural context where only meat is truly valorised.

Differences in the management of genetic resources were also observed, opposing LS to the other districts. Households in LS managed the Ri breed in open flocks, thus widening the gene pool while preventing unwanted crosses with other breeds. Moreover, slaughter decisions involved a wider range of criteria in LS compared to KS or GL. These results in LS run against the commonly assumed lack of management of genetic resources in extensive poultry systems. In accordance with their stated breed management, LS households all denied notable modifications in the Ri aspect or characteristics. Although these statements could not be corroborated by significant differences in Ri plumages across districts, this provides evidence for an appreciable involvement of LS breeders in genetic management that might be useful for conservation programs. The closer relationship of LS households with poultry is further revealed by the different perception of the temperament of the Ri chicken, felt as more tamed and calm than by interviewees in GL or KS.

4.3 Ri chicken in households' livelihoods

The place of the Ri chicken in livelihoods diverged between districts in relation with their respective distance to Hanoi. The young-to-hen ratio in LS corre-

sponds to an estimated consumption of 40% of laid eggs, a value of about 60,000 VND (2.92 USD) for egg consumption and a value of 3.22 millions VND (156.70 USD) for consumed or sold meat. Accordingly, the total annual income from poultry products would account for almost 40% of total annual income. No estimation of total income could be obtained in KS. However, by applying the same estimation method to households in KS, with annual income subject to a decrease of 0 to 25% compared to LS, the share of poultry in total income is found to stay under 20%. These results are in accordance with the share of poultry-derived income in extensive backyard systems in remote and more market-oriented households (Burgos *et al.*, 2008). The lower share of poultry in total income in KS should not be understood as a lower importance in livelihoods. In remote households, poultry keeping is needed for social inclusion and acts as a safety net and a start for economic activities.

4.4 Characterisation and performance of the Ri breed

Between the restrictive description of the Ri breed provided by the Atlas of Farm Animal Breeds in Vietnam (Su *et al.*, 2004) and the refutation of the existence of a Ri breed by some authors (Eaton *et al.*, 2006), there seems to be much room for refined consideration of intra-breed diversity. The individuals that were designated as members of the Ri breed by poultry keepers belonged to a limited array of plumages that could be included as Ri varieties by conservation programs. The red single comb appeared as a determinant criterion for the classification of a chicken into the Ri breed. The Hmong and the Choi were easily distinguished from the Ri because of their typical conformation and colour. The difference between the Ri and Mia breeds was less obvious, the only criterion being the greater size of Mia breeds. This unclear distinction between Ri and Mia breeds is further confirmed by a recent genetic study of nine Vietnamese local breeds using microsatellites (Cuc *et al.*, 2010). Tixier-Boichard *et al.* (2008) describes the concept of breed as an exclusion concept. The breed concept would thus fail to address the total genetic diversity if populations are not thoroughly or are too restrictively described, as for the Ri breed. In districts where no control of mating was stated, continuous exclusion of crossbred animals from breed consideration could ensure automatically certain homogeneity in the studied population. More precisely, their exclusion from flocks by slaughter ensures stability in the phenotype of the majority of individuals kept in flocks. Even without mating control, the breed concept appears as self-enforcing as long as the breeder uses it as a criterion in its classification and its slaughter decision. The present approach of poultry diversity through a single breed is thus restrictive but allows the identification of a local dynamic and ground for conservation and improvement.

Morpho-biometric characterisation delivered similar results in the four survey areas. However, Ri chickens proved significantly heavier in LS and at RC. Obviously, this difference can be proposed to result from selective breeding. Moreover, chickens in KS had significantly longer backs and smaller breasts, as well as shorter combs. Again, selective breeding in LS and at RC could explain these differences. In GL, due to uncontrolled mating, the existence of crossbreds between Ri and exotic chickens might be frequent. The Chinese Tam Hoang breed is widely spread and is phenotypically very similar to the yellow-feathered Ri, although larger and heavier. The Tam Hoang breed is genetically distant to the Ri (Cuc *et al.*, 2010). Hence, uncontrolled crossbreeding between both breeds could threaten the originality of the local Vietnamese gene pool. The Tam Hoang breed is further described with a larger head and less tasty meat. Facing the presence on markets of products with similar feather but dissimilar taste, consumers tend to select chickens with smaller heads in an attempt to buy “true Ri”.

The extensive system is the context in which the Ri breed expresses the advantages that are prized by breeders: resilience and maternal behaviour. Moreover, if production is aimed at different quality markets, higher weights should not be considered as an important goal. Indeed, the Vietnamese consumer often looks for smaller birds that are associated to gustative quality. In this regard the Ri breed is appreciated for its smaller size compared to other local breeds (Dong Tao ~3kg, Ho ~3.5kg, Mia ~2.5kg) (Su *et al.*, 2004). Other small sized breeds that are particularly prized for gustative quality are the Ac (~600g) and the Tre (~900g) (Su *et al.*, 2004). Likewise, the future of the Hmong breed seems to be threatened by cultural factors (namely its inadequacy with religious practices due to its black meat) rather than by its production performances. From the stated constraints and motives, it could be finally proposed to orient genetic improvement towards numerical productivity and resilience while maintaining maternal behaviour. The breeders, indeed, complained about poor egg laying performance. If such an objective is confirmed by participative consultations, breeding programs should be designed to overcome negative genetic correlation between these traits (Sazzad *et al.*, 1990).

Notwithstanding the low egg consumption in poultry keeping households, outlets do exist for eggs, as observed in LS where many interviewees commercialised the eggs. Consumers prize eggs from local breeds, recognising their smaller size as well as the orange colour of their yolk, which has been confirmed here. Thus local eggs reach higher prices on markets com-

pared to eggs from industrial strains, especially if the price per gram is calculated. Therefore, laying performance should constitute a priority among breeding goals. Specific feeding, as an element of a differentiated quality production, could enhance the deeper orange yolk colour.

4.5 Chicken and livelihoods

The proportionally greater importance of livestock to the poor is a widely accepted feature in the developing world, being also true for Vietnam (von Braun & Pandya-Lorch, 1991; Maltsoglou & Rapsomanikis, 2005). Short cycle livestock as chicken and pig are especially valuable in this regard, producing high value added by surface and time units and enhancing land cultivation productivity through their manure. In Hoa Binh province, chicken is more widespread than pig, being owned by around 82% of households vs. 70% for pig (based on General Statistics Office, 2007). Nevertheless, at the national level, pig is the most important backyard livestock, in terms of both income generation and meat consumption. This predominance leads to a prioritisation of pig production in national policies aiming at poverty alleviation, with a view to export markets (Vang, 2003; Maltsoglou & Rapsomanikis, 2005). The proposed justification is quite misleading as pigs and chickens actually fulfil very different roles inside household economy in Vietnam and thus represent distinct modes of poverty alleviation. Different household categories are targeted through both species as observed in the present study, less than 70% of chicken-keeping households also owning pigs. In contrast to pigs, chicken contributes primarily to household economy through home-consumption as reported by Maltsoglou & Rapsomanikis (2005). These authors show through a logistic regression that the probability to fall in the category of poor households decreases with an increase in the number of pigs owned and to a lesser degree the number of chicken. They also suggest a higher effectiveness of pig production in poverty alleviation. However, the investment needed for poultry keeping is low and the low individual value of chickens facilitates their acquisition and allows risk repartition. Hence, chicken is the animal of the poor and often represents a first step toward economic activities.

4.6 Future of the Ri breed

Future of Ri breeding must stay in agreement with the fundamental choice of breeders for a low-investment extensive system inside a diversified livelihood portfolio, as reaffirmed in the present survey. Evolutions towards semi-intensification or intensification is a possibility for people wanting to further specialise in the sector and is needed by the increasing demand for poultry products in urban centres. Nevertheless, indigenous breeds will not be conserved on the exclusive basis of such evolutions. Local breeds as elements of low-input systems allow access of the less-endowed people to production for domestic needs or as a start in economic activity. The necessity for these people to keep an access to resilient local breeds does not, however, preclude their usage in market-oriented systems. On the contrary, breed availability might be ensured by such initiatives. As observed in LS, some market-orientation of an extensive poultry keeping system as part of diversified activities is possible. This might even be a system of choice for in situ conservation program needing the full involvement of educated breeders. Producers as those surveyed in LS could benefit from markets and provide the economic basis for a viable conservation of the breed that could further represent a genetic pool available for more remote and less endowed households or future needs. However, if markets are helpful for conservation objectives, it will not provide the basis for conservation of an array of breed varieties as observed in the present Ri characterisation. Indeed, using a breed along with a raising system as a brand to reach the better-off urban consumer requires limiting the product to a unique and well-recognisable aspect. Therefore, markets could represent a chance for inter-breed diversity but a threat for intra-breed diversity.

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