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ENVIRONMENTAL ADAPTABILITY AND STABILITY FOR REPRODUCTION TRAITS OF LOCAL CHICKEN BREEDS

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ABSTRACT

Measurement of adaptability and stability of a breed in different environmental conditions might be assumed as good indicator for ecological, ethological and ethical norms in animal production. Indeed, a good adaptability and stability in reproduction performances, in a given environment, can be assumed as a proof that animals are in good well-being condition. The aim of this study was to assess adaptability and stability indexes for fertility traits of four local chicken breeds (the *Ermellinata di Rovigo*: PER, the *Pèpoi*: PPP, the *Robusta Lionata:* PRL and the *Robusta Maculata:* PRM) reared in three different environments (mountain, hill and plain areas) of the Veneto region. Data consisted on 338 hatchings recorded from February 2002 to May 2004. The percentages of fertile eggs per hatching (pFE), non-hatched eggs per hatching (pNH) and percentage of chicks born alive (pBA) were used as dependent variables. An ANOVA for each reproduction trait was performed to estimate genotype by environment (GxE) interaction. A high GxE interaction was detected for all reproduction traits in particular for pBA. The PER was the best breed in terms of adaptability and stability. On the contrary, the breed that showed to be poorly adapted to all environments and scarce stability over time was PPP. The PRL and PRM seem to be more similar to PPP than PER. In conclusion, more study on GxE interaction should be done to obtain more information on adaptability and stability of animal breeds in different environmental and time period conditions. Animal welfare and relationship between animal and environment should be known and subsequently used for defining better norms and rules for a modern animal production activities.

Key words: poultry / chickens / breeds / reproduction / hatching / environment / adaptation / stability

OKOLJSKA PRILAGODLJIVOST IN STABILNOST REPRODUKCIJSKIH LASTNOSTI PRI LOKALNIH PASMAH KOKOŠI

IZVLEČEK

Meritve prilagodljivosti in stabilnosti pasem v različnih okoljskih pogojih bi lahko bile dober pokazatelj ekoloških, etoloških in etičnih norm živalske prireje. Dobra prilagodljivost in stabilnost reprodukcijskih sposobnosti v danem okolju bi lahko bila dokaz, da se živali dobro počutijo. Cilj predstavljene raziskave je bil oceniti indeks prilagodljivosti in stabilnosti za reprodukcijske lastnosti lokalnih pasem kokoši (*Ermellinata di Rovigo*: PER, *Pèpoi*: PPP, *Robusta Lionata:* PRL in *Robusta Maculata:* PRM). Živali so redili v treh različnih okoljih (gorsko, hribovito in ravninsko) v regiji Veneto. Podatki, vključeni v raziskavo, so pridobljeni od 338 valjenj zabeleženih od februarja 2002 do maja 2004. Kot odvisne spremenljivke so bili v izračunu uporabljeni naslednji parametri: odstotek oplojenih jajc na valjenje (pFE), neizvaljenih jajce na valjenje (pNH) in odstotek izvaljenih piščancev (pBA). Za določitev interakcije med genotipom in okoljem (GxE) je bil za vsako reprodukcijsko lastnost opravljen izračun ANOVA. Za vse reprodukcijske lastnosti, posebej pa za lastnost pBA, je bila izračunana visoka interakcija med genotipom in okoljem. Pasma PER je bila najbolj prilagodljiva in stabilna. Nasprotno je pasma PPP pokazala najslabšo prilagodljivost v vseh okoljih in vseskozi skupno najslabšo stabilnost. Pasmi PRL in PRM sta bolj podobni PPP kot PER. Za pridobitev več informacij o prilagodljivosti in stabilnosti različnih pasem v različnih okoljih in časovnih obdobjih bi bilo potrebno opraviti še več raziskav na področju interakcij med genotipom in okoljem. Potrebno bi bilo poznati dobro počutje živali ter odnose med živalmi in okoljem ter jih v prihodnosti upoštevati pri določanju norm in pravil v moderni prireji živali.

Ključne besede: perutnina / piščanci / pasme / reprodukcija / valilnost / okolje / adaptacija / stabilnost

INTRODUCTION

Measurement of adaptability and stability of a breed in different environmental conditions might be assumed as good indicators for ecological, ethological and ethical norms in animal production. Firstly, a good adaptability and stability in reproduction performances in a given environment can be assumed as a proof of animals in a good well-being condition. Secondly, in an animal resources improvement programme it is important to assess the performance of genotypes in multi-environment conditions for identifying superior breeds for large-scale propagation. The breeders would like to have breeds that show high performance for reproduction, yield and other economic traits over as a wider range of environmental conditions as possible. However, in actual practice they perform differently in different environments, leading to alteration of their rankings in these environments. This causes difficulty in the identification of the superior's breeds and more stress and diseases for genotypes. In order to overcome these difficulties more studies on genotype by environmental (GxE) interaction should be done. Stability of a breed refers to the variability in its location-specific performance over years. A breed is, therefore, said to be stable if, in a given location its production and reproduction performances remains more or less constant over different years. In contrast, adaptability refers to the variability over environments. Thus a breed is considered adaptable if its performance (averaged over years) varies little across environments, whereas a breed is considered stable if its performance (averaged over environments) varies little across years. In the literature on GE interactions the term stability has been used in the contexts of both stability and adaptability of breeds. However, in all our discussions the separate concepts of these two aspects will be maintained. Lerner (1954) termed concept of genetic homeostasis as a static concept of adaptability when a genotype is one that shows little deviation from the expected trait level or in other words no variation in the trait over different environments. This type of adaptability is analogous to the concept of biological adaptability (Becker, 1981). Hence, the biological concept of stability can be similarly defined considering years as environments instead of locations.

In a modern and sustainable animal production system more emphases should be done for adaptability and stability of reared breeds. To reduce stress and disease of future breeds this implies that a breed that does not show GxE interaction should be better.

Aims of this study were to assess adaptability and stability indexes for fertility traits of four local chicken breeds from Veneto region (Italy) reared in three different environments (mountain, hill and plain areas).

MATERIAL AND METHODS

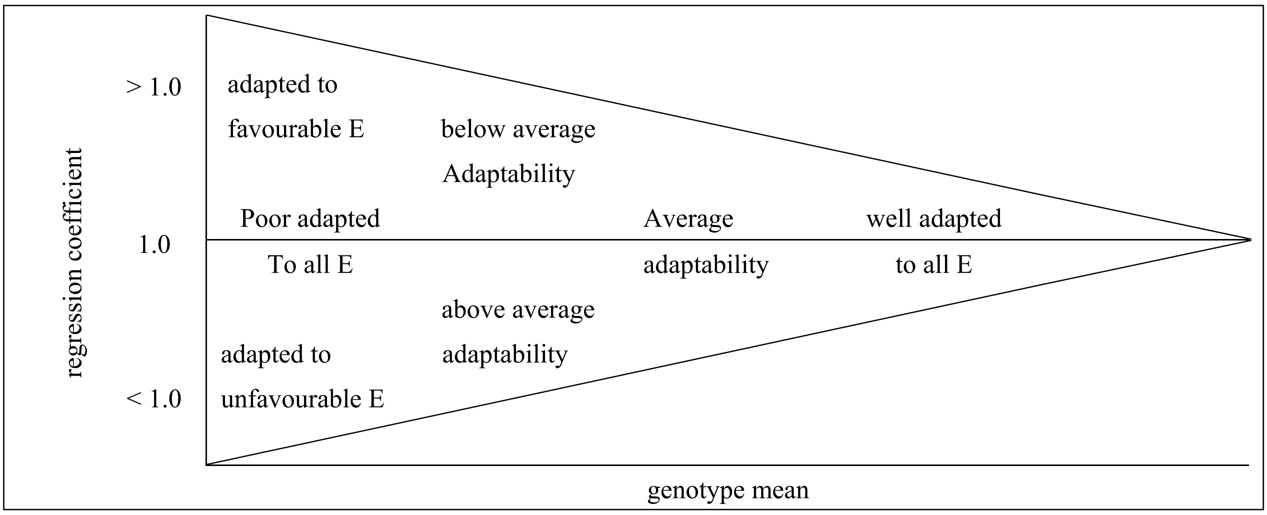
Data set analysed was based on 338 hatchings of four dual-purpose local chicken breeds from Veneto region: the *Ermellinata di Rovigo* (PER: n=85), the *Pèpoi* (PPP: n=83), the *Robusta Lionata* (PRL: n=87) and the *Robusta Maculata* (PRM: n=83). Hatchings data were recorded in three different environments with the same incubators machine and located in mountain (n=106), hill (n=181) and plain (n=51) area, respectively. The average storage time of hatching eggs before setting them into incubators was of 7 days for all breeds and locations. The three different environments were defined as herds located in mountain (Feltre-BL), hill (Montebelluna-TV) and plain (Ceregnano-RO) areas, respectively. The number of hacthings per breed per location were: a) Feltre-BL: 26 PER, 27 PPP, 28 PRL, 25 PRM; b) Montebelluna-TV: 47 PER, 43 PPP, 46 PRL, 45 PRM; c) Ceregnano-RO: 12 PER, 13 PPP, 13 PRL, 13 PRM. All breeds were reared in all areas from February 2002 to May 2004, using an organic system of production with housing in an indoor pen without artificial light and access to a grass paddock. In every herd each breed was reared with a nucleus group based on 34 females and 20 males. For, all breeds in all herds, chickens are fed *ad libitum* with the same commercial vegetable diets. Reproduction performances were estimated using picked eggs from February to May for each breed in each environment. Dependent variables were: percentages of fertile eggs per hatching (pFE), no-hatched eggs per hatching (pNH) and percentage of chicks born alive (pBA). All percentages were calculated on total number of eggs per hatching. The percentages of fertile eggs were determinated one week after incubation using external examinations with lamp. An ANOVA, for each reproduction trait, was performed with the GLM procedure of SAS (1990) package using a linear model that included fixed effect of year of hatching (Y: 3 levels), breed (B: 4 levels), environment area (E: 3 levels) and month of hatching (M: 5 levels). The genotype by environment interaction was evaluated using nested effect of B within E by Y interaction effect because of on plain herd no data were available for year 2003. Adaptability index for each reproduction performance was calculated as a linear regression of least square mean of each B per E on E mean calculated by all breeds over all years. A breed characterized by a regression coefficient not significantly different from unity is considered adaptable at an average level, so is suitable for general adaptation. If, it is gives above-average yields in all environments it is well adapted to all environments. On the other hand a unit regression coefficient and below-average yield in all environments indicates that this breed is poorly adapted to all environments. Therefore, a regression coefficient significantly greater than unity will mean that the breed is highly sensitive to environmental change, i.e. it shows very little resistance to such changes (below-average adaptability). For a high yielding breed, this means that a small change in the environments in the positive direction may result in large response and hence this breed is suitable for specific adaptation in favourable environments. A breed with a regression coefficient less than unity would offer greater resistance to environmental changes (above-average adaptability) and so is specifically adapted to poor environments. A graph representation of different adaptive groups, depending upon the combinations of regression coefficient and genotype mean is showed in Figure 1.

One of the most interesting findings of the empirical study of Finlay and Wilkinson (1963) is that the variability (between genotypes) in adaptability, as measured by the regression coefficient is inversely proportional to the mean yield. In other words, genotypes with general yielding ability (judged by the average yield over locations) show above average adaptability while the adaptability of varieties with low mean yields ranges from one extreme of the other.

Similar comments can be used for calculating stability index estimated as linear regression of least square mean of each B per Y on Y mean calculated by all breeds over all environments.

RESULTS AND DISCUSSION

The statistical description of reproduction traits analysed are summarized in Table 1. Around one hundred eggs per hatching were available, with an average of 0.3/0.4 number of eggs/female/d showing a moderate production performance of the dual-purpose local chicken breeds considered. A minimum value of zero was found for pFE, pNH and pBA when only 2 eggs were available for hatching. Percentages of fertilized eggs, no-hatched eggs and chicks born-alive showed a very high variability with a coefficient of variation ranged from 30% to 67%. Highest coefficient of variation was for no-hatched eggs that showed a higher skewness index (+1.39), respect to fertilized eggs and chicks born-alive (–0.60 and –0.03, respectively). Average and standard deviation of reproduction traits per chicken breeds are showed in Table 2. The PER breed showed the highest performances for pFE (75.2±38.9) and pBA (61.5±14.0) whereas the lowest pNH (11.1±9.2) was obtained by PRL breed.



E = environments

Figure 1. Graph representation of genotype adaptation (Finlay and Wilkinson, 1963, modified).

Analyses of variance for pFE, pBA and pNH are showed in Tables 3, 4 and 5, respectively. The R^2 were 54%, 32%, 59% for pFE, pBA and pNH, respectively. For all reproduction traits all effects were statistically significant. The high significant effect of the environment within YB showed a presence of a GxE interaction for reproduction traits that seem to be high for pBA.

Table 1. Statistical description of reproduction traits of 338 hatchings

Trait	Mean	S.D.	Minimum	Maximum
Eggs per hatching, n.	104.5	45.5	2.0	231.0
Fertilized eggs, % (pFE)	60.2	18.5	0	92.7
No-hatched eggs, % (pNH)	15.5	10.5	0	67.6
Chicks born alive, % (pBA)	44.0	19.5	0	100.0

Table 2. Mean (±SD) of reproduction traits per chicken breed

Trait	PER	PPP	PRL	PRM
Hachtings number, n	85	83	87	83
Eggs per hatching, n.	125.9 (38.9)	79.8 (39.4)	94.8 (44.1)	117.5 (44.9)
Fertilized eggs, % (pFE)	75.2 (12.4)	54.3 (16.6)	53.3 (18.9)	58.1 (16.6)
No-hatched eggs, % (pNH)	12.7 (6.5)	18.5 (11.9)	11.1 (9.2)	20.1 (11.0)
Chicks born alive, % (pBA)	61.5 (14.0)	36.4 (17.4)	41.2 (18.3)	36.6 (16.3)

PER: Ermellinata di Rovigo; PPP: Pèpoi; PRL: Robusta Lionata; PRM: Robusta Maculata.

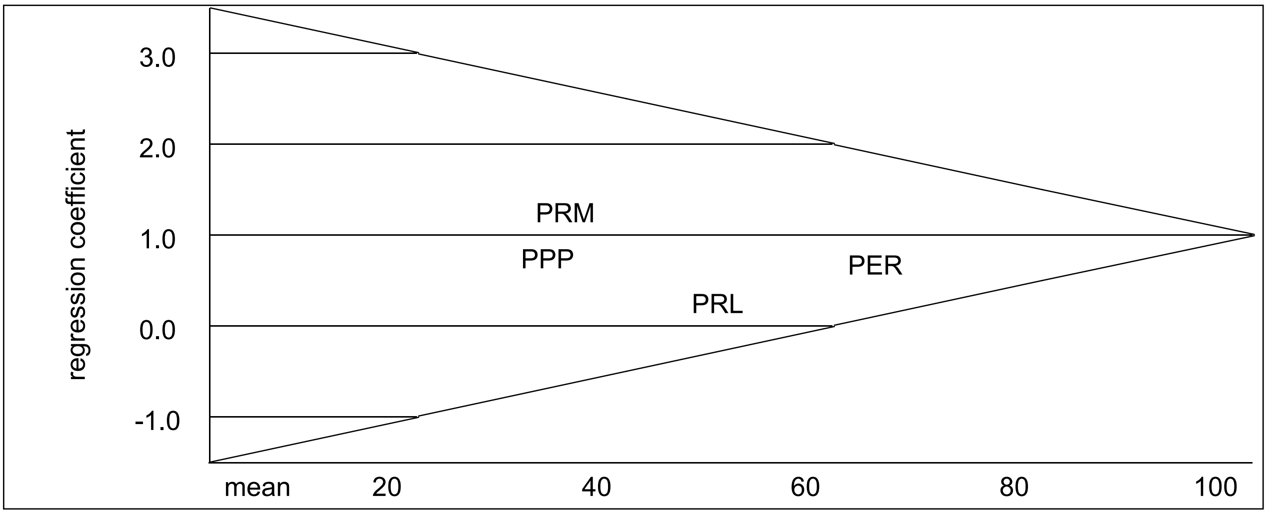


Figure 2. Graph representation of adaptability index for percentage of chicks born alive

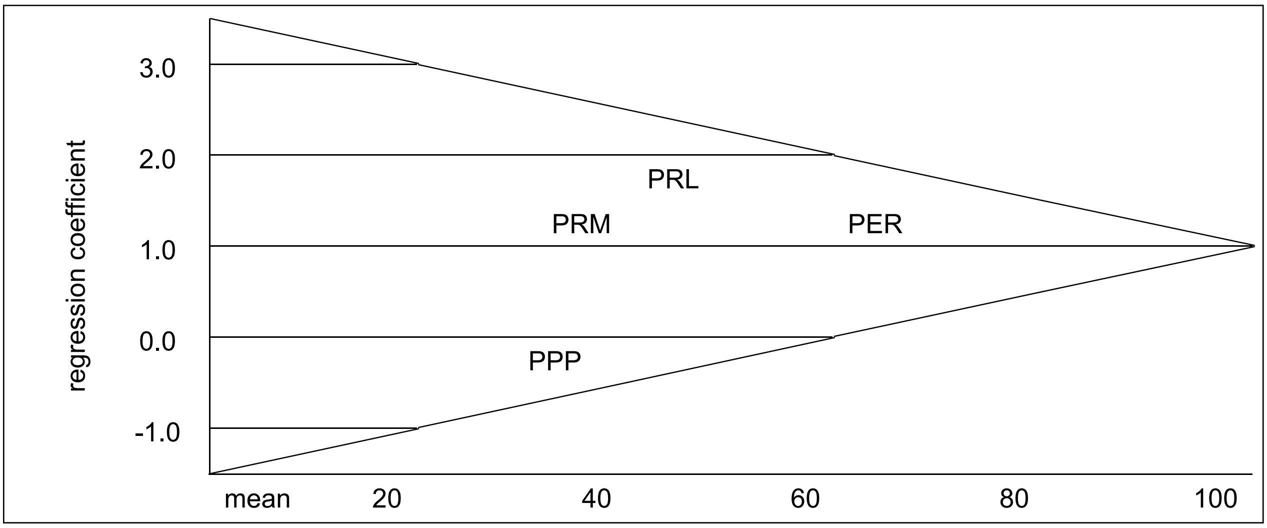


Figure 3. Graph representation of stability index for percentage of chicks born alive

In Tables 6 and 7 are showed adaptability and stability indexes for all reproduction traits per each breed.

Table 3. Anova for percentage of fertilized eggs per hatching (Type III)

Source of Variation	d.f	MS	F	P
Year of hatching * breed (YB)	11	0.2666	2.91*	0.0184
Environment within YB	20	0.1174	5.26	<0.0001
Month of hatching	4	0.2074	11.90	<0.0001
Error	302	0.0174		
R^2, %	54			

*test of hypotheses using type III mean square for environment within YB as error term.

In terms of adaptability the breeds that showed to be more sensitive to environmental change (below-average adaptability) were PRM for all reproduction traits and PRL for pNH. At the contrary, the breeds that showed to be more resistance to environmental change (above–average adaptability) were PPP for all reproduction traits and PER for pFE and pBA. The PER for pNH showed a general adapatation also in different environments.

Table 4. Anova for percentange of no-hatched eggs per hatching (Type III)

Source of Variation	d.f	MS	F	P
Year of hatching * breed (YB)	11	0.0626	3.36*	0.0090
Environment within YB	20	0.0186	2.23	<0.0022
Month of hatching	4	0.2838	3.40	<0.0097
Error	302	0.0083		
R^2, %	32			

*test of hypotheses using type III mean square for environment within YB as error term.

Table 5. Anova for percentage of chicks born alive per hatching (Type III)

Source of Variation	d.f	MS	F	P
Year of hatching * breed (YB)	11	0.3945	3.60*	0.0063*
Environment within YB	20	0.1095	7.80	<0.0001
Month of hatching	4	0.1010	5.86	<0.0001
Error	302	0.0172		
R2, %	59			

*test of hypotheses using type III mean square for environment within YB as error term.

Table 6. Adaptability index (coefficient of regression) of reproduction traits for chicken breed

Trait	PER	PPP	PRL	PRM
Fertilized eggs, % (pFE)	0.641	0.649	0.113	1.644
No-hatched eggs, % (pNH)	0.918	–0.435	1.876	1.231
Chicks born alive, % (pBA)	0.643	0.839	0.544	1.431

PER: Ermellinata di Rovigo; PPP: Pèpoi; PRL: Robusta Lionata; PRM: Robusta Maculata.

Table 7. Stability index (coefficient of regression) of reproduction traits for chicken breed

Trait	PER	PPP	PRL	PRM
Fertilized eggs, % (pFE)	1.195	–0.515	1.717	0.599
No-hatched eggs, % (pNH)	0.674	1.195	1.712	1.259
Chicks born alive, % (pBA)	1.142	–0.152	1.605	1.045

PER: Ermellinata di Rovigo; PPP: Pèpoi; PRL: Robusta Lionata; PRM: Robusta Maculata.

In terms of stability the breeds that showed to be more sensitive to period (year) change (below-average stability) were PRL for all reproduction traits, PRM and PPP for pNH, and PER for pFE. At the contrary, the breeds that showed to be specifically stable to unfavourable period change (above–average stability) were PPP for pFE and pBA, PER for pNH and PRM for pFE. The breed that showed an average stability was the PRM whereas the breed that showed to be well adaptable to all period was PER. In Figures 2 and 3 is showed the graph representation of adaptability and stability indexes, respectively, for percentage of chicks born alive.

CONCLUSIONS

The ecological, ethological and ethical norms in animal production might be defined measuring adaptability and stability of a breed in different environmental conditions over several years or time periods. Indeed, animal's well being and reproduction performances can be affected by specific environmental conditions based on temperature, climate, and altimetry. In the present research, an approach was proposed to estimate adaptability and stability indexes for four local and unselected chicken breeds reared in different environments over three years. A high GxE interaction was detected for all reproduction traits in particular for pBA. The PER breed showed to be the best breed in terms of adaptability and stability with a general adaptability to all environments and with a well stable reproduction performances over time. On the contrary the breed that showed to be poorly adapted to all environments and scarce stability over time was PPP. The PRL and PRM seem to be more similar to the PPP than the PER. In conclusion, more study on GxE interaction should be done to obtain more information on adaptability and stability of animal breeds in different environmental and time period conditions. Animal welfare and relationship between animal and environment should be known and subsequently it used for defining better norms and rules for a modern animal production activities.

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