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Research paper

Allometric coefficients for carcass and non-carcass components in a local meat-type sheep breed☆

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A B S T R A C T

The aim of the research was to assess the type of development of carcass and non-carcass components and tissue partitioning in the Cornigliese sheep breed. The study involved 164 animals (104 females, 60 males) from one flock. The selection of those animals accounted for ages and weights differences. Fasted body weight (BW) was recorded before slaughtering. Four BW-classes were identified by means of percentiles distribution: 0–25th percentile, 15.90–50.70 kg BW; 25th–50th percentile, 50.71–63.22 kg BW; 50th–75th percentile, 63.23–75.50 kg BW; 75th–100th percentile, 75.51–111.15 kg BW. After slaughter, the carcasses were weighed, measured (carcass length, croup width, chest width, chest depth, thigh length) and sectioned (shoulder, neck, thigh, ribs, loin, and lean and fat trimmings). A samplecut from 1st to 4th thoracic vertebra was then separated into its tissue components (lean meat, fat, bone). Non-carcass components (skin + fleece, head, liver, heart, lungs + trachea) were weighed. The data were analyzed using a GLM procedure accounting for the following fixed effects: sex, BW-class, year of birth and the interaction between sex*BW-class and the covariate: day of slaughter. The relative growth of carcass and non-carcass components on BW was calculated by applying the nonlinear allometric function ($y = ax^b$). We found high coefficients of variation (CVs) (from 39% to 77%) for the weight of carcass components and low CVs (from 8% to 22%) for carcass measures. Non-carcass parameters showed intermediate values of CVs (from 30% to 42%). Body weight-class had a significant effect ($P < 0.05$) on all parameters, except on lean/fat ratio and lean percentage of the sample cut. Significant mean differences between genders were observed in the lean/fat ratio. In particular, in the lowest BW-class, females scored higher than males, whereas, in the highest BW-class, we observed the opposite trend ($P < 0.05$). Carcass, loin, lean and fat trimmings grew faster than BW, regardless of the sex. In contrast, as far as the neck is concerned, significant differences between females and males were observed ($P < 0.05$). Among carcass measures, a late maturing rate was recorded for croup width ($b = 0.5042$) and, in this case, females tended to be earlier than males ($P < 0.10$). Among non-carcass parameters, only head and skin + fleece weights showed differences between sex groups, with males showing a later development than females ($P < 0.05$). Tissues (lean, fat, bone) in the sample cut developed with different speed: the earliest tissue was bone ($b = -0.3191$), followed by lean ($b = 0.0768$) and finallyby fat ($b = 0.8394$). Bone development was significantly ($P < 0.05$) sex related, with males showing a later growth than females. Sex differences in the sample cut composition were also associated to lean/fat, (lean + fat)/bone and lean/bone ratios. This study has shown the potential use of the Cornigliese sheep as a commercial breed for meat production, although significant interaction between sex and body weight was observed. For this reason, it is recommended to implement a breeding strategy to reduce the incidence of extreme fattening females and the high incidence of non-carcass component in males when they reach high BWs.

1. Introduction

Nowadays, the conservation of biodiversity has become an important topic in animal husbandry, since it leads to control genetic variability in small populations and to preserve the cultural background and economic sustainability of rural territories (Davoli, 2011). Via the breeding of local breeds, the connection between breed, territory and typical products is strengthened, thus, allowing potential novel forms of incomes. The first step in unravelling the potential use of local breeds for production is to explore their economically relevant traits via phenotypic recording system; moreover, their economic valuable aptitude must be enhanced and exploited and every possible genetic support

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must be applied, not only to maintain the genetic variability but also to improve and analyze their genetic level (Gandini and Oldenbroek, 2007). The use of genomic tools (Ouborg et al., 2010) has paved the way to further explore the genetic background of relevant traits in animal breeding. However, GWAS studies (Genome wide association study) require phenotypic data to be linked to genomic data (Stock and Reents, 2013). Thus, increasing the collection of phenotypic records is a key factor, not only for the effective use of genomics, but also for any type of genetic improvement or conservation programme (Food and Agriculture Organization Commission on Genetic Resources for Food and Agriculture, 2015).

For these reasons in this study, we further explored economically relevant traits, such as the development of carcass and non-carcass traits in the Cornigliese sheep breed. The Cornigliese sheep breed is an autochthonous breed reared in the Emilia-Romagna region (northern Italy). Up to date, even though this breed has been mainly used for meat production (Beretti et al., 2006; Sabbioni et al., 2016b), no formal breeding schemes have been applied. Additionally, previous studies showed the potential use of this breed for wool (Beretti et al., 2004) and milk production, both in terms of quantity (ASSONAPA, 2017) and quality (Franceschi et al., 2006).

In the last years, several projects on the conservation and preservation of Cornigliese sheep breed have been proposed, as well as studies about the genetic structure of the population (Ceccobelli et al., 2015). Those initiatives have led to increase the number of individuals belonging to the Cornigliese breed, from 50 animals in the 1990s (Food and Agriculture Organization, 1994) to 1035 in the beginning of the 2000s (Cecchini, 2006). More recently, the number of animals registered as Cornigliese breed has been recorded as about 1600 animals (Sabbioni et al., 2016b).

Since the increased popularity of the Cornigliese sheep breed, the presented study further explored the potential use of this breed for meat production. In particular, the aim of this research was to assess the type of development of carcass and non-carcass traits and tissue partitioning in the Cornigliese sheep breed by applying allometric coefficients.

2. Material and methods

2.1. Animals

The trial was conducted at a slaughterhouse, under the control of the public veterinary service following the Italian laws on experimental animal welfare (LD 04/03/2014, n.26).

The research involved 164 animals (104 females, 60 males) belonging to the Cornigliese sheep breed, born from 2013 to 2016. They were raised in one flock located in a mountain area of the province of Parma (Italy), at about 800 m of altitude, latitude 44°24′50″04 N and longitude 10°7′30″72 E. Animals were fed differently with regards to the season. From spring to autumn, they were fed with natural meadow grass pastures and a supplement of concentrates, whereas in winter, they were relocated in enclosed facilities. For further details on the feeding strategies, refer to Sabbioni et al. (2016a). Under the standard rearing conditions of Cornigliese sheep breed, the wool shearing took place twice a year, in spring and autumn. All animals were dewormed (Ivomec Ovini Sc, Merial Italia SpA, Milano) during spring.

2.2. Measures

The animals were slaughtered during 11 different sessions (from 8 to 26 animals slaughtered per session) subdivided in different months as follow: March (2 sessions), May (3 sessions), June, July, October, November (1 session) and December (2 sessions). Animals were selected for slaughtering to be representative of a wide range of ages (females from 3.6 to 80.0 months; males from 3.6 to 61.7 months) and body weights (females from 15.90 to 111.15 kg; males from 19.00 to 108.10 kg). Carcasses sectioning was performed always by the same specialized operators.

Before slaughtering, the body weight (BW), after 12 h of fasting, was recorded with the use of a calibrated dynamometer (model CCS–300 K, UWE, Taiwan). Based on BW at slaughter, animals were then assigned to one of four BW-classes, identified by means of percentiles distribution: 0–25th percentile, 15.90–50.70 kg BW (n. = 42); 25th–50th percentile, 50.71–63.22 kg BW (n. = 40); 50th–75th percentile, 63.23–75.50 kg BW (n. = 42); 75th–100th percentile, 75.51–111.15 kg BW (n. = 40). After slaughtering, the hot carcass weight was recorded; non-carcass components (skin + fleece, head and offal, represented by liver, heart and lungs + trachea) were also weighed. Dressing percentage was calculated as (hot carcass weight/BW)*100. Linear measurements on carcass were recorded using either a measuring strip or a compass. In particular, the following parameters were evaluated: carcass length (from the midpoint of the front face of the atlas to the articulation of the last sacral vertebra with the first caudal vertebra); croup width (maximum width at the level of trochanters); chest width (maximum width at the level of the ribs); chest depth (from the dorsal margin of the fifth thoracic vertebra, at the point of articulation with the sixth, to the midpoint of the ventral margin of the penultimate sternebra); thigh length (from the cranial margin of the pubic symphysis to the medial malleolus) (Borghese et al., 1991). After chilling for one week at 4 °C, the left half-carcass was sectioned and the shoulder, neck, thigh, ribs, loin, and lean and fat trimmings were weighed (Borghese et al., 1991). A sample cut (in correspondence of the first four thoracic vertebrae) was then collected after sectioning, and refrigerated to be transported to laboratory facilities. This sample was then separated into its tissue components, to assess the incidence of lean meat, fat and bone. Furthermore, the following ratios lean/fat, (lean + fat)/bone and lean/bone were also calculated.

2.3. Statistical analysis

All the raw data were preliminarily submitted to a normality check, using the PROC UNIVARIATE function (SAS, 2012) and resulted normally distributed. An analysis of variance was then conducted, based on PROC GLM, with the following fixed effects: sex (2 levels), BW-class (4 levels), year of birth (4 levels) and the interaction between sex*BW-class. The day of slaughter was included as a covariate. The relative growth of carcass and non-carcass components on BW was then calculated by applying the nonlinear allometric function ($y = ax^b$), as described by Sabbioni et al. (2016a). In this case, "y" is a dependent variable (carcass or non-carcass parameter or sample cut component, in g or %), "a" is the intercept, "x" is the independent variable (BW, in kg) and "b" is the allometric coefficient (Stevens, 2009; Strauss, 1987). Comparisons of the equation parameters between sexes were performed by means of the Student *t*-test, using the pooled estimates of standard error to determine significant differences (Pilla, 1985).

3. Results

Table 1 shows the descriptive statistics of carcass and non-carcass parameters recorded on Cornigliese sheep breed, as well as of those related to the sample cut composition. The weight of carcass components showed high coefficients of variation (CVs) (from 39% to 77%), while low CVs (from 8% to 22%) were recorded for carcass measures. Non-carcass parameters showed intermediate values for CV (from 30% to 42%). The highest CV (88%) was calculated for lean/fat ratio and the lowest (7%) for lean percent in sample cut.

Overall, the analysis of variance revealed that BW-class was a significant factor for the majority of the parameters, with the exception of lean/fat ratio and lean percentage in the sample cut (Table 2). In addition, year of birth was a significant source of variation for many parameters (22 out of 25). The remaining sources of variation in the statistical model (sex, sex*BW-classand slaughter session, defined as covariate) were significant for a lower number of parameters (9, 11 and