Genetic Management of Tunisian Holstein Dairy Herds

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In Tunisia, the recognition of the possibility of including longevity and disease resistance in dairy cattle selection objectives has been hypothesized as a useful strategy by both researchers and producers.

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1. Introduction

For the modern dairy cow, advances in genetics and breeding for productivity have resulted in an increased incidence of health disorders and reduced longevity. However, to maintain farm sustainability, farmers need to optimize the balance between maximum production and minimum production costs [1]. Moreover, reduced profitability is associated with the costs of dairy herd health and fertility, which are also major causes of involuntary culling. Nevertheless, reducing the incidence of disease in dairy cows is of economic, social, and environmental importance. Therefore, dairy cattle selection around the world has focused on increasing milk production due to consumer demand and the impact of production on farm profit margins. This was extremely successful through the combination of genetic selection with improvements in nutrition and health management. On the other hand, Oltenacu and Broom [2] indicated that inefficiencies exist because the increased production has led to negative effects on health, reproduction, and longevity. Miglior et al. [3] insisted on the inclusion of functional traits, such as fertility, health, and longevity, and reported that these traits have both economic and socioeconomic impacts through improving animal welfare and the sustainability of dairy production.

Brickell and Wathes [4] suggested that extending the productive life of cows reduces replacement costs, allows for more limited selection, and increases the potential milk yields from adult cows, thus improving milk production. Generally, the culling rate was higher for low-producing cows and older ages at first calving. In addition, higher-producing cows are found to be culled at an earlier age than low-producing ones. M'Hamdi et al. [5] concluded that cows at the start and end of the first lactation and at the end of all other lactations were at the highest risk of culling. Tunisian dairy herds reported an average culling rate of 15–22% [5], with more than 50% of the cullings resulting from involuntary causes such as infertility, mastitis, and lameness [5][6]. In addition, Heikkilä et al. [7] reported that mastitis and lameness are the costliest diseases for dairy farmers as they cause sharp declines in milk production and farm income. Agiri et al. [8] reported that the true herd lifespan of Tunisian Holstein-Friesian cattle averaged 41.99 months, corresponding to a production life of 3.5 years, and the number of cows culled after the first two lactations reported that only 7.14% of cattle remained, compared to 57% in their fifth lactation. The genetic improvement program of Tunisian Holstein dairy cow has been elaborated since the 1960s to strengthen this sector; recording, performances control, AI, and Herd-Book are implemented and performed by the «Office de l'Elevage et des Pâturages (OEP)» [9]. Large phenotypic databases are continuously evaluated in collaboration with universities to track the pedigree of herds of animals, register their performance, and use them to implement herd genetic tendencies and management.

2. Animal Health, Diseases, and Welfare

The health and welfare of all animals in the dairy herd are paramount for profitable and efficient milk production. The disease is often measured by economic impact, but animal health is also part of animal welfare. The pain and discomfort caused by health problems affect an animal's well-being, so animals must be in good health to improve animal welfare [6]. Records of the incidence and prevalence of various diseases are made more readily available through farm record-keeping systems. Producers must be able to correctly identify specific animal health problems early to improve animal welfare and herd health. Unfortunately, in Tunisia, there is no systematic recording system of health events in dairy herds [5]. This lack of information concerning health problems and their impact on dairy cow productivity prohibits work on the genetic analysis of the health and diseases of the dairy herd [5]. However, evidence of culling can partially compensate for this lack of information. Examining data for screening can be a cost-effective alternative compared to the costs of collecting, storing, and analyzing data on health disorders. Mastitis and lameness are major problems in Tunisian herds. Mastitis is a production, food quality, and safety issue. From an animal welfare perspective, it is a localized and painful infection for cows that can cause systemic illness leading to fever, dehydration, depression, and even death, depending on the type of infection and the cow's resistance. However, mastitis has been assessed during somatic cell counting. A prospective study of 21 selected dairy farms in northern Tunisia was conducted by Mtaallah et al. [10] to assess the reduction in milk yield due to high somatic cell counts in bulk tanks and to find associations between the risk factors and asymptomatic mastitis. The authors found that the average somatic cell count of bulk milk was 626,103 cells/mL and the average milk loss due to the somatic cell count in bulk tanks was 524 kg per cow per year. The risk factors associated with high in-tank somatic cell counts include: (i) livestock risk factors (inadequate bedding area, inadequate cleaning of bedding and waste areas); and (ii) milking risk factors (tap washing with showers without adjustable flow and individual towels. No wiping, more than five milking shifts per cow-herd; no overspray before milking or milking healthy and mastitis cows at the same time; no teat dipping). M'Hamdi et al. [11] analyzed the data, consisting of 73,189 test-day records of somatic cell counts, for the three first lactations of 8350 Holstein cows calving between 1997 and 2003 in 114 dairy herds. The results showed that the milk yield (MY) was largest in the second control, at 25 ± 9 kg, and lowest in the tenth control (14 ± 6 kg).

Lameness among dairy cows is widely recognized as one of the most serious (and costly) animal welfare issues affecting dairy cattle. Lameness is the third most common infection in cows in modern barns. Environmental factors (diet, stables, injuries) and genetic factors are responsible for this condition. Lameness is also recognized as an important welfare problem, causing pain, and impairing the cow's ability to exhibit normal behavior [12][13]. In a study conducted by Ferchichi et al. [14] in Tunisian dairy herds, the incidence of lame cows averaged 67%. However, Bouraoui et al. [15] showed that podal pathologies have an incidence equal to 38.71% (score > 2). They reported that the incidence of lameness was approximately 37% and 99% in the second and third parities, respectively. The authors found that the prevalence was higher in heifers than in primiparous cows and that lameness occurred more frequently in Winter and Autumn than in Summer and Spring because the animals were reared under temperate climate conditions, where the cows' environment may be wetter in Winter and Autumn. The rate of lameness increased by 2%. Regarding the most economically important disorders in dairy cows, mastitis, infertility, and claw and leg disorders are listed [16]. A Tunisian study was conducted on 35 dairy farms to assess the welfare quality of Tunisian Holstein cattle based on several animal welfare indicators validated by the European Welfare Quality Project. The avoidance distance (on the face and in the stall), physical condition, lameness, fertility, somatic cell count (SCC; cells/mL), and milk yield were assessed [17]. The main results showed that the SCC averaged 427.3 ± 90.12 10^3, being the highest in Autumn and associated with milk yield. Milk yield increased with the number of lactations and varied by the lactation stage. Smaller farms had lower somatic cell counts. The same study reported that the body condition score (BCS) ranged between 1.25 and 4 (lactating cattle) using a BCS scale between one and five. Most cows presented a BC score of 2.5 (50% of cows); however, most dry cows presented a BCS of 2.75 (65% of cows), ranging between a BCS of 1.5 and 4. A BCS of two or less was classified as 'thin'. The mean number of lactating cows in this category on all farms was 18.9 ± 1.9%. As for lameness, the proportion decreased, with only 19 out of 350 cows (5.4%) showing moderate lameness. Lameness appears to have been the greatest welfare problem within the parameters investigated. In general, the avoidance distances are short, which is an indicator of good human-animal relations and may reflect good farming practices [17]. In dairy herds, some bacterial diseases (*Bovine tuberculosis, Campylobacter enteritis*, Anthrax, Hemorrhagic septicemia, *Mannheimia haemolytica*, and Contagious bovine pleuropneumonia, etc.) are of paramount importance, particularly those considered zoonotic. Among these, *Bovine tuberculosis* (caused by infection with *Mycobacterium bovis*) is perhaps the most problematic. Heritability estimates on the observation and responsibility scales varied between 0.06 and 0.18; the standard errors varied between 0.012 and 0.044. The presumption of inheritance was based on the tuberculin test response and the presence of tuberculosis lesions confirmed during slaughterhouse testing. These results demonstrate that gene truncation can achieve a significant improvement in tuberculosis resistance [18]. *Bovine tuberculosis* (bTB) is considered a major zoonosis in Tunisia and a break to the intensification of production. Tunisia has had a national bTB control program since 1984. It is based on the intradermal tuberculin skin testing of dairy cows and regular meat inspections at the slaughterhouse. Nonetheless, bTB remains prevalent, mainly in the private sector, where disease control is based on sparse veterinary practices and slaughterhouse testing without routine intradermal tuberculin skin testing [19]. In their synthesis on animal health and disease genetics, Berry et al. [20] concluded that the accurate quantification of genetic trends in most health traits is not possible due to the lack of the routine availability of accurate animal health records and data in most countries. Nonetheless, past genetic trends may be predicted based on the estimated genetic correlations with the production traits, and the impact of these correlations can be quantified using the knowledge of past breeding goals.

3. Association of Longevity with Fertility and Type Traits

3.1. Fertility

Reproductive disorders reduce fertility, prevent conception, cause problems in delivering healthy calves, cause postpartum complications, increase inter-calving intervals, reduce milk yield, and affect overall life expectancy [21]. Among the many factors that influence the age of replacement in primiparous cows, reproductive disorders are particularly important [22]. Under Tunisian conditions, the optimal primal age was 23–27 months. Reducing the age of replacement to about 24 months may improve the 305-d and longevity yields and extend the swarm longevity [23]. Medium-performing cows tended to stay in the herd longer than low-performing or high-performing cows. Shorter-than-expected residence times in prolific cows can be explained by selection for reasons other than production (involuntary selection), such as poor health and reduced fertility. These results are comparable to those by Ducrocq [24] and Weigel et al. [25]. The phenotypic correlations between the actual herd life and the milk, fat, and protein yields ranged between −0.04 (open day) and 0.06 (calving interval) on the fertility parameters [8]. Environmental factors (year of calving, season of calving) and management factors (herd) are very important sources of variability in milk production, reproductive traits, and thus herd lifespan. A combination of clearly defined reproductive goals and better management (such as selection for low production, selection of non-yield traits, and diversified feed sources) improves the performance of Tunisian Holstein cattle [8]. Functional lifespan (FL) or productive lifespan (LPL) length is an important trait for measuring the overall functional fitness in cattle. The effect of age at first calf on the milk yield and actual herd life span was investigated in Tunisian Holstein cattle. Ajili et al. [8] investigated 33.407 first lactating records for cows born between 1987 and 2001 from 166 herds and found that the herd life expectancy was 38.6 months (SD = 24 months) and the mean age at first birth was 28.7 months (SD = 3.4 months). The backward mean heritability for age at first delivery was 0.08.

3.2. Type Traits

Type traits are currently being measured as part of the genetic improvement programs aimed at linking trait types with milk production, conformation, reproduction, and longevity. The purpose of including type traits is to improve the conformation of cattle by providing better body and functional and reproductive structures so that they can meet the challenges of increased production [3]. Linear traits are used to select for longevity, mainly because all trait types are acquired early in cattle life and have moderate heritability [26][27]. Selecting the types of traits associated with herd longevity can be beneficial in reducing involuntary selection and increasing profitability [28]. Type traits that have a significant impact on a cow's longevity are those associated with the udder, feet, legs, and leg sections, for example, anterior attachment, texture, depth, posterior mammary attachment height, posterior mammary attachment width, median ligament, and bone quality. and trunk angle [29]. The selection of the hind mammary width and height, mammary structure, mammary cleft, loin strength, bone quality, and final score may improve the longevity and milk production [30]. Zavadilová and Štípková [31] found a positive genetic correlation between longevity and type traits, BCS (0.14–0.19), tail angle (0.15–0.21), and hook quality (0.05–0.19). A slightly weaker correlation was found in the results (−0.13–0.02). Both the true and functional longevity were tested, and the type traits showed stronger genetic correlations with functional longevity. Kern et al. [32] found similar results for the type traits. The correlation between lifespan and paw angle was in the same range of −0.18 to 0.08 [32] and −0.10 to 0.10 [31]. The correlation between the type characteristic and udder depth was positive, with the longevity characteristic 0.20–0.27 (that is, the taller the breast, the longer the longevity) [33], 0.04–0.11 [31], and 0.17–0.31 [34]. Zavadilová and Štípková [31] found a negative correlation with the median ligament type trait (−0.19). [28] found a positive correlation (0.28) for the breast-supporting trait, which is considered to be the same as the median ligament, and a positive correlation (0.17–0.29) for the posterior papillary trait. Setati et al. [33] observed a low heritability of longevity and moderate heritability of most types of traits, except for lump height and pre-papilla length. All of the phenotypic correlations between lifespan and linear traits were slightly positive (0.01–0.09). The genetic correlations between longevity and breast features and angles were moderate-to-high and positive (0.22 to 0.48). In conclusion, the positive genetic correlations and moderate heritability suggest that the selection of udder features and angles could improve longevity in dairy cows [35][36].

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