

Review Article

A Review on the Effects of Broodiness Characteristics on Egg Productivity, Hatchability, and Chick Quality of Indigenous Chicken in Ethiopia

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Abstract

Broodiness is an action or behavioral tendency to sit on a clutch of eggs to incubate and hatch them, with non-expression of other behaviors such as feeding and drinking and, it is due to the secretion of the hormone prolactin by the anterior lobe of the hypothalamus. It is breed-dependent, some breeds have the highest long last incidence, some may have less and the others may not. Breeds such as Cochins, Cornish, Siskies, Quails, Pheasants, Turkeys, and Geese have a high tendency to broodiness but in some breeds such as the White Leghorn, broodiness is extremely rare. The Ethiopian indigenous chickens are none descriptive breeds closely related to the Jungle fowl and vary in color, comb type, body conformation, and weight and different broodiness behavior. The poultry breeding programs that is used to improve the productivity of indigenous chickens should target economical traits and consider the current and future production circumstances. Even though the broodiness characteristics of indigenous chicken is considered as antagonistic to egg production, it plays a pivotal role in rural and smallholder poultry production for subsistence poultry keeping and product utilization due to effective and successful maternity characteristics of hen for sustained and growth of chicks.

Keywords

Brood Hen Egg Productivity, Hatchability, Maternal Character

1. Introduction

Broodiness is an action or behavioral tendency to sit on a clutch of eggs to incubate and hatch them, with non-expression of other behaviors such as feeding and drinking. The broody hen might be acknowledged as a natural incubator for operational efficiency and effectiveness. Although broodiness is associated with reduced egg production, it contributes a significant role in enhancing the rural poultry population by supplying chicks [1]. Broody hens can be de-

fined as "Being in a state of readiness to brood eggs that are characterized by cessation of laying and by marked changes in behavior and physiology. Broody hens often pluck feathers from their chest and abdomen, using them to cover the eggs. Then, they develop one or several patches of bare skin on the ventral surface. These reddish, well-vascularized areas of skin are usually called brood patches, and improve heat transfer to the eggs. The Indigenous chickens lay two or three

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Received: 21 November 2024; **Accepted:** 6 December 2024; **Published:** 30 December 2024



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clutches per year and are well known for their broodiness characteristics. The broodiness character is usually suppressed in commercial layers but dominant in indigenous female chickens. Due to this natural instinct, production is probably hampered in chicken [2].

On a physiological basis, broodiness is due to the secretion of the hormone prolactin by the anterior lobe of the hypothalamus. Broodiness is initiated physiologically by an increase in the concentration of the hormone prolactin beyond a threshold that is three to four times higher than that which is present during the egg-laying phase [3]. When a hen becomes broody, it will stop laying and start incubating eggs and will later care for the hatched chicks. The onset of incubation is coincident with complete regression of the ovary, a considerable regression of the comb, and a characteristic clucking.

Broodiness is considered a hindrance to high egg yield under commercial production conditions. However, small-holder poultry production systems in developing countries require hens that can incubate the eggs, due to the impossibility of artificial incubation [4]. From a genetic resource point of view, indigenous hens are vital for maintaining a natural source of egg incubation, given that the high-yielding breeds have been manipulated to such an extent that they are unable to survive without the support of humans [5].

2. Review on Characteristics of a Broody Hen

The Ethiopian indigenous chickens are none descriptive breeds closely related to the Jungle fowl and vary in color, comb type, body conformation, and weight. Broodiness (maternal instinct) is pronounced. They are characterized by a slow growth rate, late sexual maturity, and low production performance. The mean annual egg production of indigenous chickens is estimated at 60 small eggs with a thick shell and deep yellow yolk color [6].

According to [7], the productivity of indigenous chickens (expressed in terms of egg production, egg size, growth, and survivability of chicks) kept under the traditional production system is very low. The low productivity of the indigenous chickens could be attributed to a lack of genetic improvement, the incidence of diseases, and predation and management factors [8].

2.1. Production Performance of Indigenous Chicken

The productive performance of indigenous scavenging chickens of Ethiopia is low because of their low egg production potential, high chicken mortality, and longer reproductive cycle (slow growth rate, late sexual maturity, and broodiness for an extended period [9].

Even though the productivity of local chickens is very poor, they are very important to withstand certain harsh en-

vironmental conditions and can perform better under poor management than cross and exotic breeds and they have desirable characteristics such as an ideal mother, good sister, hatch their eggs, excellent foragers, resistance to common poultry disease and special meat and egg quality (flavor), hard egg shells [10].

The low productivity of the indigenous stock could also partially be attributed to the low management standard of the traditional household poultry production system. It has been seen that the provision of vaccination, improved feeding, clean water, and nighttime enclosure improve the performance of the indigenous chickens [11].

Traditional free scavenging is the common production system (no adequate supply of feeding, housing, and health care). This production system results in poor productive performance of indigenous chickens such as low egg production performance, small-sized eggs, long sexual maturity of hens and cockerels, high chicken mortality, and chickens' exposure to predators) [12].

2.2. Hatching Performance and Chicks' Survivability

The hatchability may vary due to differences in breed, environments, and season in the countries. However, even though average egg weight is almost the same, there is a tendency to decrease the hatchability with the higher weight of broody hens, where upper weight class hens had a little lower hatchability.

2.3. Effects of Broody Hen on Egg Production

Broodiness can be described as the transition from egg layer to egg hatcher. As a broody cycle begins a hen will still lay the odd egg but as broodiness builds all egg-laying will stop. Egg laying is an energy-intensive activity but a broody hen's energy will be focused on raising her body temperature to keep existing eggs nice and warm as opposed to laying more. Broodiness does temporarily lead to a hen laying fewer eggs.

Chicken possesses natural prosperity towards early cessation of egg-laying. This is due to the basic desire to incubate a clutch of eggs to ensure the survival of the species. This intrinsic desire is accompanied by behavioral and physiological state associated with maternal care of the unhatched eggs termed incubation behavior. A high level of circulating plasma prolactin suppresses the secretion of gonadotropins, which are directly responsible for the regression of the ovary, the decrease in plasma ovarian steroids, and ultimately the termination of egg production in chicken [1, 13]. Good layers have moderate baseline prolactin levels throughout egg production. Incubation behavior constitutes a major cause that leads to early cessation of egg-laying and remains a significant source of economic loss for rural poultry keepers.

Although, it is difficult to eradicate incubation behavior

there are some managerial techniques and strategies used to prevent it and to improve egg production based on lowering baseline prolactin. These techniques involve; moving hens from their familiar pens to different surroundings or less comfortable areas without nests, frequent collection of eggs from the nests, provision of a uniform lighting system that discourages nesting in dim corners, and improving slow and insufficient ventilation rate. Furthermore, a successful immunization of female turkey with synthetic chicken Vasoactive Intestinal Peptide (VIP) resulted in increased egg production [14].

2.4. Breeds Selection for Breeding Replacement

The practice of selection on breeding and replacement of female chickens is based on the different criteria that are set and indicated. In most parts of the country, farmers ranked the first criteria of selection the egg size bird laying and reproduction performance (Broodiness and hatchability). The selection practices are not only limited to the traits categories which influenced market price and directly or observed and/or measured on the selection candidate itself. The most important traits of farmers give attention to are growth rate, disease tolerance, egg yield, body size, and fertility. The majority of the farmers may be considered the egg yield as the most important trait followed by mothering ability and body size [14].

Identification of traits of economic importance is vital in the development of breeding objectives. Therefore, breeding programs for improving the productivity of indigenous chickens should target these traits and consider the current and future production circumstances. Under circumstances of extreme poverty where people cannot keep larger species of livestock due to a shortage of land and capital, village chickens provide high-quality animal protein as the source of production and income for household activities such as education, health, and clothes. These benefits from family poultry production go directly to the rural poor, in most cases to the women being most active as caretakers [14, 15]. In addition, chickens are also important for diversifying agricultural production and increasing household food security directly to the rural poor community including increased distribution of resources through the involvement of women.

Ethiopia has a large population of chickens estimated to be 50.38 million [16]. With native chickens of the non-disruptive breed. Concerning breed, 96.9 percent, 0.54 percent, and 2.56 percent of the total poultry were reported to be indigenous, hybrid, and exotic, respectively [17]. The contribution of village chickens to farm households and rural economies is not proportional to their high numbers, although they contribute more than 98% of the total meat and egg production in the country. This is mainly due to low productivity levels which are the result of diseases, poor management in terms of feeding and housing, poor growth rates, and predation [18].

The use of broody hens to incubate eggs and rear chicks is common in Ethiopia. The profitability of a poultry farm is dependent on the hatchability of the breeding hens and the degree of chick survivability. Thus, information on knowledge of local egg selection practices, practices of egg storage, ways of breaking broodiness, methods of egg fertility testing, incubation practices, rate of hatchability, and techniques of chick brooding are of paramount importance in identifying interventions areas use as baseline information for improvement programs to ensure sustainable improvement and utilization village poultry. Little research has been done on incubation and brooding practices of village chickens under a scavenging system in the country [18, 19].

2.5. The Purpose of Keeping Local Chickens

The purposes of keeping poultry by households in Ethiopia are for income generation and home consumption [20]. With a minimum priority for incubation and security. However, by the report [21]. The main function of chickens for farmers is the provision of meat and egg for home consumption. Poultry production has an essential economic, social and cultural benefit and plays a significant role in family nutrition in developing countries. In many countries of the world, poultry is kept as scavengers in and around the residential areas at a village and family level [11, 22].

Village chickens are the easiest livestock species to the rear by any household member in every corner of the globe since they are less labor-intensive and required low inputs. They have a pivotal role in the improvement of growth, mental development, school performance, and labor productivity and reduction of the likelihood of illness among the small-scale farmers 'children through diversification of consumable foods Influence of Broodiness on Egg Production and Laying Ability nonbroody hens produce more eggs than broody hens and the percentage of hen-day egg production [23].

Laying Nest Management and Egg Storage

A laying nest for a broody hen is prepared from different materials and placed in different manners. A bamboo basket bedded with Teff straw, a nest on the ground, and a nest under the bed are the common laying nest preparations. Changing the bedding materials during incubation is practiced. A shallow depression in the ground are common material and location used as egg setting sites, and crop residues of Teff, wheat, and barley straws were used as bedding materials in different agro-ecological zones of Ethiopia [24]. Most local breeds of chicken's exhibit broodiness even in cage systems [25]. In breeding programs for local breeds, eradicating broody genes remains a selection goal, and removing broody hens when broody behavior is exhibited is a common strategy. However, in some cases, broody hens also exhibited superior laying ability when the broodiness is not expressed. Therefore, in breeding programs for indigenous chickens, it is recommended that although the removal of broody hens is

accomplished by the selection, greater attention should be given to providing an environment to stop the expression of this behavior. Village poultry is an available asset to local populations throughout Africa and they contribute to food security, poverty alleviation and promote gender equality, especially in the disadvantaged group such as children, women, and poor farmers, and less favored areas of rural Africa where the majority of the poor people reside [1, 26].

They have an important role in social, cultural, and religious importance, and are considered "an entry point for poverty reduction and gateway to national food security" because it has the potential in boosting living standards, and social needs and improve family nutritional status [27]. In Ethiopia, most farmers have always used broody hens to incubate eggs and rear chicks. The profitability of given poultry industry is highly dependent on the hatchability of the breeding hens. Hence, the information on indigenous knowledge of egg selection, brooding, egg storage, incubation practices, brooding breaking techniques, fertility testing methods, and factors that affect hatchability (constraints) have played a key role in the identification of key points to improve the hatchability of chickens and serve as baseline information or input for the development of agro-ecologically based and holistic improvement programs to ensure sustainable improvement, utilization, and conservation of chicken genetic resources [18, 19, 28].

3. Production Constraints of a Broody Hen

The most priority constraints of local chicken production are the diseases affecting long last productivity and survivability followed by the lack of locally adapted and well-performing chicken breeds in the country. Unavailability and poor quality of feeds, low management skills, predators attack, lack of modern technologies, and uncontrolled breeding are the common findings in extensive chicken production systems [6, 29].

3.1. Common Characteristics of Broodiness in Local Chicken

The term "broody" refers to a hen that stops laying eggs to sit on the eggs, even when there is none in the nest box. Broodiness is breed-dependent, some breeds have the highest long last incidence, some may have less and the others may don't. Broody hens can be aggressive, so caution must be taken during handling.

A backyard hen that lays 5 or 6 eggs, whether they have been fertilized or not, is likely to become broody if the clutch of eggs is not removed from her. After a clutch of eggs is laid, a hen's behavior changes, and she becomes a broody. This may be the desired quality if the owner wishes a hen to incubate her own fertilized eggs; it may be an undesirable trait if

the purpose of the hen is to lay eggs for human consumption or to produce fertile eggs for artificial incubation.

Most hens will recover from their broodiness in 2 to 3 days without intervention, and some hens may remain broody for 3 to 4 weeks. From an endocrinological perspective, the following physiological changes is occurring when the hen is in the broody stage. The purpose of brooding is to keep the eggs warm. The hen develops a brood patch towards the end of the egg-laying period, and the skin becomes edematous and highly vascularized. Brood patches develop in response to ovarian steroid exposure. The tactile stimulation of the de-feathered, edematous brood patch triggers the transition from egg-laying to brooding due to prolactin release. The blood flow to the brood patch is greatly increased, such that the heat from the skin in this area incubates the eggs. Sensory fibers detect skin temperature where there is skin-to-egg contact. If the hen's body temperature falls she will shiver to generate heat and increase her metabolism to ensure that eggs are at the optimal temperature for incubation [30].

The brooding period ends when prolactin levels decline. Behavior related to incubation of eggs is no longer evident or occurs with very low frequency in major commercial stocks against which broodiness has been selected. Incubation behavior of hens is a common characteristic in most chicken stocks until a few decades ago. As the need for natural incubation and maternal care of chicks became obsolete, because of artificial incubators and chick brooding equipment, broodiness came under closer examination. Broodiness is a trait involving sex-linked genes confirmed by [31]. Broodiness is successfully selected against by commercial breeders is not surprising; it appears to be at least moderately heritable [1, 32], most experiments indicated that it is negatively associated with total egg production, and it is easily identified during the first year of egg production [33]. The behavioral exhibition is controlled by both internal and external factors. Internal factors are mainly neuroendocrine factors. Neurons of the central nervous system can change structure and functions (neuronal plasticity) to adapt to a given environment and which, in turn, affects animals' behavioral exhibition [34].

The broody hen is appropriate for households as a hen can incubate two or three clutches of eggs in a year. Traditionally indigenous hens are used both for egg production and subsequent hatching of eggs. Although broodiness is a hindrance to good egg production, the broody hen is doing a great job to hatch the chicks at very low costs [11, 35].

The broody hen is also the best trainee for their offspring in showing them how to look for feeds and to tackle adverse situations i.e. finding protection from predators. In most cases, people probably put more eggs than the hens can hatch, and become lost due to this way. The matter is important, as egg production from indigenous chicken is only 35 to 45 eggs per year [2, 36].

3.2. Broody Hen Selection for Incubation Purposes

Broodiness is a vital characteristic of traditionally managed local birds and the physiological mechanism is a prerequisite to sustaining the present system at least until local farmers start to use other means of incubation. Normally, once a bird becomes broody and is not used for hatching eggs, she will remain broody for 3-4 weeks. Traditionally, households attempt to increase egg production by stimulating broody birds to resume egg laying. The basis for these practices is to disturb the broody bird and to cause a hormonal shift so that it starts to lay eggs again within 8 -10 days.

Because of this human interference, the number of clutches and eggs produced /year /bird is increased. If the hen hatches eggs it will stay with its brood for up to eight weeks. Some farmers set eggs under two birds at the same time, and after hatching give all the chicks to one of the hens. However, regular stimulation of birds to resume egg-laying as a measure taken by households to improve the laying performance of hens increases egg production by about 80% and is testimony that chicken ecotypes are shaped not only by the environment but also by human intervention.

The Ethiopian indigenous chickens are none descriptive breeds closely related to the Jungle fowl and vary in color, comb type, body conformation, and weight. Broodiness (maternal instinct) is pronounced. They are characterized by a slow growth rate, late sexual maturity, and low production performance. The mean annual egg production of indigenous chickens is estimated at 60 small eggs with a thick shell and deep yellow yolk color [6, 27].

The broody hen will show the following signs; Clucking, Staying away from the rest of the flock, ruffled feathers, Aggressive and protective of the nest, and sitting on the nest at night. Natural incubation uses a broody hen to incubate eggs by sitting on them in a nest. Broody hens, when available, work best for small clutches of eggs. Broodiness, the behavior of a setting hen, has been bred out of some chickens. Broody hen has the advantage of incubating and hatching eggs in the absence of electricity, without the intervention of humans the hen will do all the work and will brood chicks after they hatch and the fertile eggs will have a high hatchability rate. The broody hens for incubation should be selected based on different selection criteria plumage color, body weight (large size), broody behavior, and mothering ability (good hatching history good protector from predators /aggressive weaning the bird, good feeder, and good ability of setting).

3.3. Traditional Methods of Breaking Broodiness

In the smallholder poultry production system, households use different traditional methods of breaking broodiness to increase egg production by stimulating broody hens to restart egg-laying. These techniques are practiced as moving to

neighbors, hanging upside down, piercing the nose and tying the wings, and disturbing the nest for a couple of days are effective in breaking broodiness within 3 to 4 days. For the more stubborn hen, a wire-bottomed cage is necessary.

The airflow up through the wire keeps her underside cool and after a few days she will usually give up. Again, she should have feed and water available at all times. Some commercial people and old-time chicken raisers deprive a hen of feed and water when trying to break her up, but this is cruel and will affect the animal well fair and is also not good for the bird. Lack of feed weakens an already weak bird (since they don't eat much when broody anyway) and lack of water for several days can damage the liver. Putting a 'clutch' of ice cubes under her is another method to break broodiness [38]. The hens resume laying soon after breaking broodiness increasing total annual egg production. This result is in agreement with that of [39]. The higher egg productivity (143 eggs/hen/year) by the Ethiopian indigenous chickens with the proper management of broody hen.

3.4. The Traditional Egg Fertility Testing Techniques

The traditional egg fertility and hatchability testing techniques practiced by the smallholder farmers of the country are floating eggs in water, shaking, and candling into the sun [40]. The production potential of backyard chickens can only be increased when there are adequate numbers of viable chickens available for the replacement of the uneconomical birds. This is mainly a function of the quality of the eggs set for hatching [40]. The higher the proportion of quality eggs, the better hatchability. Backyard chickens are scavengers, and there seems to be a wide variation in their hatching performance compared with commercial poultry. The hatchability variation range between 63.1 - 84.1% of eggs under backyard conditions [42]. Hatchability is affected by several factors including nutritional and health status, genetic factors, and physical, storage, and incubation conditions of the eggs. Seasonal fluctuations could also cause wide variability in hatchability. A prolonged egg-holding period may cause deterioration in the interior egg quality and increase the risks of embryonic mortality [43]. The number of eggs set under a broody hen could also affect hatchability. It is suggested that incubation of a single egg beyond the capacity of a broody hen could result in a reduction of hatchability by 0.23% [40]. Hatchability and rate of chick survival are one of the major determinant factors of productivity in poultry.

3.5. Incubation Practices and Hatchability

The production potential of backyard chickens can only be increased when there are adequate numbers of viable chickens available for the replacement of the uneconomical birds. This is mainly a function of the quality of the eggs set for hatching. The higher the proportion of quality eggs, the bet-

ter hatchability. Backyard chickens are scavengers, and there seems to be a wide variation in their hatching performance compared with commercial poultry [44].

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The number of eggs set under a broody hen could also affect hatchability. It is suggested that incubation of a single egg beyond the capacity of a broody hen could result in a reduction of hatchability by 0.23% [46].

Hatchability and rate of chick survival are one of the major determinant factors of productivity in poultry. Commonly incubate eggs during dry seasons and use "hamattu" (clay pot with straw bedding) as an incubation box. Researchers witnessed that there are a large amount of genetic discrepancy in chicken reproduction performances in Ethiopia and this indicates the existence of divergent subpopulations within the chicken population that gives room for genetic improvement between and within subpopulation [47]. The success of the hatching and brooding process depends on the maternal instinct of the broody hen and the prevalence of predators in the area, such as birds of prey, pets, and some wild animals, all of which are listed as the major causes of premature death of chicks in Ethiopia [48].

4. Conclusion

This review concludes that the Ethiopian indigenous chickens play an important part in a balanced farming system that has vital roles in the rural households as a source of high-quality animal protein and emergency cash income and play a significant role in the socio-cultural life of the rural community and woman lifestyle empowerment. One of the most important positive characteristics of native chickens is their hardiness, which is the ability to tolerate the harsh environmental condition and poor husbandry practices without much loss in production. The native breed chickens are the reservoir of genomes and major genes for the improvement of high-yielding exotic germplasm for tropical adaptability and disease resistance. There are different farmers' practical activities, which are recommendable methods used to break and shorten the length of time for broodiness in laying hens such as stopping access to the coop (nest), sending or changing them to chicken jail (travel box), frequent egg collection, and offering feed and water. It is also important to mix the chicks from less broody hens to strong broody hens.

Abbreviations

CSA	Central Statistical Agency
EH	Egg Hatchability
EP	Egg Productivity
RSHD	Rural Self-Help Development

VIP Vasoactive Intestinal Peptide

Author Contributions

Seyoum Bekele: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing original draft

Sileshi Gadisa: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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