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Review Article

The Links Between Hormones and Aggressive Behaviours in Animals

Elohozino Oghale Benneth[1,2]*, Emmanuel Onche[1], Isaac Babatunde Fasipe[1] and Abdulsabur Adebayo Aderemi[1]

[1]Department of Animal Welfare Science, Food and Agricultural Technology Unit - The Pan African Research Group, Nigeria

[2]Research Unit, One Health and Development Initiative, Nigeria

***Corresponding Author:** Elohozino Oghale Benneth, Department of Animal Welfare Science, Food and Agricultural Technology Unit - The Pan African Research Group, Nigeria.

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Abstract

Animal behavior is influenced by so many factors which must be deeply studied and understood. One of such factors is hormones, which significantly influence animal aggression. Currently, there is no definite conclusion on how aggression is influenced by hormones, although there is continuous research on it. The essence of this review is to investigate the relationship between hormones and aggression. It is concluded that several hormones aid in eliciting aggressive behavior in animals by playing a crucial role due to the high effects, they have on the neural system. However, they do not cause the animals to be aggressive on their own alone.

Keywords: Aggressive Behaviours; Hormones; Animals; Parent-Offspring

Introduction

There are so many dynamics that influence animal behavior, and a better understanding of both physiological and biological bases is very essential aids for the further enlightenment of such behaviors. The role of hormones in monitoring behavior, especially as regards aggression, has undergone a lot of study from different scientists around the world for several years, but without any tangible finding [23]. It is still being studied for further clarification. While hormones affect the individual who secretes them either physically, emotionally, mentally or behaviorally, aggression affects an opponent individual or group of individuals within the reach of the aggressive individual for several reasons such as territorial, parental, sexual, dominance, predatory, irritable, parent-offspring and anti-predatory. Most times it is dependent on the environmental circumstances the aggressive animal finds itself. The purpose of this essay is to look at the link between hormones and aggression. I will look at how the link between hormones and aggression is studied, and how the environmental circumstances of an animal can influence the secretion of certain hormones that stimulate such aggressive behaviors from the animal.

Hormones

A lot of explanations and descriptions of hormones have risen as a result of their major function in the body or the influences or effects they have on target tissues when at certain levels in the body system. There is a published sequence of detailed reviews of Growth Hormone and reproduction in 2000-2002 [26]. Just like the previous research works, the current models incorporate data from clinical, agricultural, and experimental studies. In addition to incorporating recent articles, we have reinterpreted the role of Growth Hormone in reproduction in light of two major conceptual developments: firstly, that autocrine/intracrine Growth Hormone may put forth various functions from endocrines. The second point is that Growth Hormone may have destructive consequences on neoplasm development and insulin resistance.

Hormones can be explained: "as chemical substances either by specialized ductless glands located in various parts of the body or by neurons, called neurosecretory cells, within the nervous system and are in most instances referred to as neurosecretions." According to Moroz, [31] these neurosecretory cells are specialized nerve cells that disseminate chemical stimuli by producing secretions known as neurohormones. These when secreted are transported in the bloodstreams to their target organs. Also, because hormones are transported to different portion of the body via the bloodstreams where they act on target tissues thereby producing physiological effects, they are indirectly linked to behavior. Simpson [39] gives further insight on how hormones engage in cell permeability alteration giving rise to relevant effects on membrane potential, ion concentration, synaptic transmission, neural communication and therefore, behavior. This is because a lot of influences occur as a result of their presence in organisms, although not their principal role, alterations are made on neural activities because of them. However, hormones being chemical substances have a particular concentration at which they can act in the body. Marshall and Hughes [30] explain hormones as molecules that are physiologically very vigorous acting in the body in very low concentrations of about 10^{-10} molar. Therefore, there has to be a balance of stimulation and subdual to attain dynamic stability so that hormonal levels can be maintained. Although hormones yield more incremental modifications than nerve impulses, there are certain occurrences where there is a speedy endocrine organization such as the effects of adrenaline or the reaction of the stomach to gastrin. On some occasions, however, hormones may act aggressively to nerve impulses. The nerve impulses and hormonal secretions both make use of the feedback mechanisms which sheds more light on the fact that an increase in the concentration of specific hormones in the blood triggers off a negative feedback response in the hypothalamus-pituitary complex which decreases its additional secretion [30]. Impulses from the sense organs pass unto the cerebral region and finally into the hypothalamus usually when an animal is faced with conditions occurring either in individual forms or in combined forms such as anger, pain, fear, heat, cold etc.

According to Houngbadji., *et al.* [24] Corticotropin-Releasing Factor (CHF) is then produced in the hypothalamus and is released into the anterior pituitary thereby causing the release of Adrenocorticotropic hormone (ACTH) which simultaneously enhances the secretion of hormones by the adrenal cortex. Concurrently, the nerve impulses not introduced in the hypothalamus then make their way to the sympathetic system as well as to the adrenal medulla thereby secreting adrenaline and noradrenaline hormones. These hormones are referred to as Hormonal Catecholamines which according to Haller., *et al.* [21]. Carter and Goldstein [4] "appear to be incorporated in metabolic practices for the forthcoming fight, further pointing out that while the sympathetic system ensures appropriate cardiovascular reaction, the CNS noradrenergic system prepares the animal for the prospective fight." However, Marshall and Hughes [30] clarifies that "it is the adrenaline secreted that strengthens the action of the sympathetic system thereby preparing the body for one of these responses which are depending on the nature of the animal and the surrounding conditions at that particular time." These responses are known as the "fight or flight" hormonal stimulators. Stating that it is also responsible for vital occurrences in the body of the animal which when combined eventually leads to an increase in the amount of energy instantly obtainable to the animal. Such occurrences include an increase in the release of ACTH from the pituitary, the release of sugar from the liver, an increase in heartbeat and respiratory rates, a decrease in blood flow to the gut and inhibition of peristalsis. Noradrenaline on the other hand is responsible for causing blood to exit gut muscles and other areas of the body that have no vital role in the direct survival of such fight or flight situations. In addition, Haller., *et al.* [21] indicate that "as regards more aggression-specific effects, a person may observe that a trivial instigation of the central nervous system arouses aggression, while a strong instigation declines the willingness to fight to reveal that this biphasic effect may allow the animal to participate in or avoid the fight, which is dependent on the strength of communal challenge. Aside the studies that have concentrated on adrenalin and noradrenalin: the catecholamine hormones, other studies carried out on hormones like testosterone, prolactin, estrogen, progesterone amongst other hormones have been shown to also influence aggressive behaviors in animals.

In the case of testosterone, most studies have shown a very close linkage between the hormone which is secreted by androgens and its influence on aggression. Some studies, however, discuss that there is a vital period shortly after birth when testosterone prepares certain neural pathways in the brain which when stimulated at adulthood by steroids will prompt aggression [8]. Also, Edwards, [11] points out that stimulating androgens in animals at a very early stage instigates the differentiation for the aggression of a neural system thereby making it more sensitive to androgen in adulthood unlike when the neural system is formed without the presence of neonatal androgenic stimulation. Birger., *et al.* [2] mention the effects of testosterone in influencing aggressive behaviors that occur after aromatization. Giving further explanations that testosterone acts as a prohormone which when converted into 5-alpha dihydrotestosterone will act on androgen receptors, or when converted to estradiol will act on estrogen. In one study, female rats that had undergone ovariectomy were injected daily with certain levels of testosterone, estradiol or a placebo. Discoveries were made that testosterone increased aggressiveness, which was measured by the regularity of fighting, whereas estradiol or placebo had little effect [44]. It is also observed that circulating testosterone is also influential in the structures and signals used during fights giving examples of stags and male mice. According to them, a strong, aggressive reaction is observed in male mice due to the scent of another male's urine which is a result of the breakdown products of testosterone contained in the urine. For stags, Clutton-Brock., *et al.* [7] point out the influence of increasing testosterone levels is needed for the enlargement of their neck muscles for effective roaring during RUT. Although testosterone can control several neurotransmitters at diverse levels showing proof of the influential effects of aggression, it is only one of the various factors that influence it which shows that there is also a strong correlation sometimes between the environmental motivations and the effects of previous experiences [39]. While the levels of testosterone are significantly lower in females than in males, the link between testosterone and aggression is not seen in the male species only. Cashdan [5] reported a positive linkage between testosterone and aggression and similar behaviors in women.

Prolactin is a maternal hormone that acts as an intermediary either as the psychological or physical tie between the mother and its young. It acts in conjunction with Oxytocin which is another maternal hormone responsible for milk-let-down in animals. The prolactinergic and oxytocinergic systems control these modifications amidst other neurohormonal substrates thereby prompting the mother to identify any possible endangerments and in course of doing that overcomes her suspicions and apprehension against trespassers or predators as a means of protecting her young. Studies from Gleason., *et al.* [17] using a white-footed mouse (*Peromyscus leucopus*) illustrates how prolactin influences aggression. It shows that females were not aggressive after the removal of their ovaries (ovariectomy). But when injected with an intermediate dosage of prolactin, they became as aggressive as lactating females. Suggesting that there may be a synergistic action of prolactin and progesterone or some other adrenal hormones that stimulate aggression in females.

Estrogen is a group of hormones primarily influencing the female reproductive system during its developmental stage, functional stage and maturity in which estradiol is the predominant hormone. Many studies however have conducted experiments on the level of an effect estrogen and estradiol have on aggression in animals. Estradiol, however, which is the most potent estrogen, is synthesized from testosterone [43]. Schlinger and Callard [38] using Japanese quail (*Coturnix japonica*) as an animal model showed that aggression is influenced by estradiol stating that individual differences in behavioural intensity are correlated with aromatase in the hypothalamus/preoptic area (HPOA). From the studies of Steinman and Trainor [41], the environmental sensitivity on estrogen-dependent mechanisms of aggressive behaviors in which photoperiod plays an important role is highlighted. Trainor., *et al.* [42] in their experiments to determine the effects of photoperiod on aggressive behavior using the California mice (*Peromyscus californicus)* and Beach mice (*Peromyscus polionotus*) ensuring that estrogen receptor alpha and estrogen receptor beta immune-staining did not differ in the lateral septum, medial preoptic area, bed nucleus of the stria terminalis, or medial amygdala made the following discoveries. Estradiol rapidly increased aggression in males housed in short days than males housed in long days. Suggesting that the rapid action of estradiol on aggression in short-day mice also shows that non-genomic mechanisms mediate tthe effects of estrogens in short days. This is also shown in the figure below.

Photoperiod is a determinant of aggression as a result of the effect of estradiol injection. Estradiol injections improved aggression within fifteen minutes if sheltered under winter-like short days but had no the effect when mice were housed under summer-like long days [42].

Aggression

Aggression is a genetic trait in hounds, but the intention is contrary to the behavior. Pigs and cattle aggressive techniques towards the handler are often related to improved motherly behavior [22], which is a positive trait in the mothering ability of these hormones in metabolism and behavior. Many researchers [18,28] have documented how catecholamines and biochemical routes are included in the expression of stress and fear.

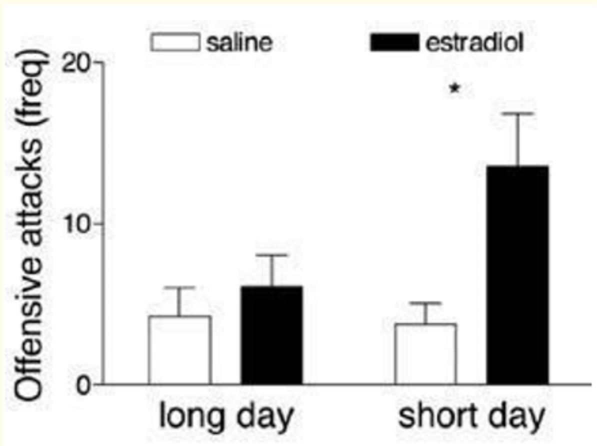

Figure a

Improved blood flow to the brain as a result of the activation of the catecholamine system year analyzed [40]. Sympathoadrenal segment of the autonomic response is negotiated by catecholamines-epinephrine. Activation of the hypothalamic-pituitary-adrenal axis is manifested by the release of glucocorticoids from the adrenal cortex and operates independently of stressful situations [12]. Rodriguez., *et al*. [37] used biomarkers and found variations in plasma concentrations of norepinephrine, substance P and β-endorphin in a study in which pain rough lameness in cows was analyzed. Our knowledge of aggression is made up of several pieces of information gathered from various parts of the world as a result of diverse species where coordination aggressive behavior may differ remarkably. According to O'Neill., *et al.* [34] aggression can be defined as "animal behavior that solves actual or potential harm to another animal which could either be interspecific aggression, in which animals' prey upon or defend themselves from other animals of different species, and intraspecific aggression, in which animals attack members of their species". Maremmani., *et al.* [29] illustrate it as a behavior intentionally displayed to inflict harmful or destructive effects upon another individual either of its species or another. While Drickamer and Vessey [9] sees aggression as a complex phenomenon having so many functions with many causes which includes predatory behavior whereby the animal being attacked is terribly injured or eaten in the process.

O'Neill., *et al*. [33] is of the opinion that labeling all behavior aggressive is a matter of opinion as some of these behaviors often n results in settling status, superiority or access to some object or space resulting a precise distinction must be made between criteria relating to consequence e.g. infliction of injury and those relating to causation e.g. intent. O'Neill., *et al.* [35] however implies that there are certain cues or stimuli which an animal that shows aggressive behavior could respond to before attacking another animal as the immediate reason or drive responsible for such attacks. Some of these cues could be olfactory, visual, auditory or tactile. In the case of visual cues Nehls [32] cites examples of how Robins will assault with great ferocity any red equipment or object which could range from feathers, handkerchief, socks etc. placed in its territory, mistaking such objects as trespassers. And in the case of auditory cues, robins will barrage a tape recorder dabbling the song of another robin when placed in its territory. Olfactory cues in male mice arouse forceful behaviors when it perceives the scent of another male's urine. In the case of tactile cues, spiders emit vibrations and use them in various instances. According to Klarner and Barth [27] orb weavers are known to make a kind of echolocation plucking the individual radii of their web thereby confining prey or other elements weighing as little as 0.05mg. Fox [13] however points out that there are many forms of aggression which are normal as well as enables survival of the fittest and are altered through hormonal influences, genetic influences (hereditary) and early experiences (learned) considering them to be innate and acquired elements that ultimately adds up to the aggressive potential of the animal in question. Wilson [46] list the various forms of aggressive behaviors as follows: Territorial aggression which is aimed at excluding other animals of same species or different species from some physical space; Dominance aggression which is aimed at being in charge or in control due to previous experience of the behavior of a conspecific; Sexual aggression usually by males aims at using threats and physical displays to obtain and retain female mates for breeding purposes; Parental aggression which occurs in order to attack intruders so as to protect their young; predatory and anti-predatory which is aimed at preying on another animal and a defensive attack by prey on predator; and finally Parent – offspring aggression which involves the disciplinary actions of the parent against their young occurring mostly during weaning.

Hormones and aggression

Investigations in Aves have contributed greatly to acknowledging the neuroendocrine restriction of aggression [47]. The first study of hormones and aggressive behavior was performed in roosters in the 19th Century. More recently, field studies of wild so Parent-offspring central in solving hormone-connection across seasons and atmospheres. Collective field–laboratory approaches in Aves have generated novel insights into the social restriction of testosterone levels, the express behavior section during the non-breeding and cost of elevated circulating testosterone levels [19] neuroendocrine mechanisms are not particular to song sparrows and may be present in maybe their avian species. For example, various species that breed in the tropics protect sovereignty year-round and have very low levels of distributing sex steroids throughout the year. Aggressive behavior and neonatal exposure to testosterone is necessary for normal expression of intermale aggression in mice [1,14]. The VMH usually comprises in reproductive and social agonistic behavior and may be involved in protective reactions [3].

Having understood some of the influences hormones have on aggression, examples will be given in this section citing the possible hormones that could be influencing such aggressive behaviours. Male mouse perceiving the scent of another male's urine within its territory prompts its territorial aggression, due to the traces of testosterone breakdown in the intruding male mouse's urine enabling it to decipher that it is a male intruder. Here the hormone testosterone is seen as the influencing factor behind such aggression and if it comes in contact with the Intruding male mice the fight hormone (adrenaline) influences it further. In the example of the stag, during RUT which is their breeding season, roar and grunt in order to compete for admittance to hinds by committing in ostentatious shows of authority including rumbling, similar walks and battle. Prominent stage then ensures restricted breeding with the hinds (Clutton-Brock., *et al.* [7]. This type of aggressive behavior combines both dominance and sexual aggression and is usually as a result of the influences of testosterone, adrenaline and possibly estrogen. Another example is fighting between male bullfrogs which occurs so as to establish territories with larger males usually winning and controlling the better sites. Females preferentially mate with these males and lay eggs in their territories [25]. Sexual and territorial aggression is observed here as well as adrenaline, testosterone and possibly estrogen playing an influential role in such aggressive behaviors. In dogs for example, a female whose new litter is under 10 days will be much-more anxious and protective of her puppies than she will be 8-weeks later when her puppies are more independent and mobile. Also there's a distinct possibility that a normally wary dam who now has a neonate litter, will snap at a stranger who tries to handle her newborns. Wilson [45] using German shepherds observed aggressive behaviors between the mother and its puppies, noting that as the puppies grew nursing behavior decreased while grooming behavior increased. In this case maternal aggression which falls under parental aggression combines with parent – offspring aggression. The influencing hormones are prolactin, progesterone, estrogen, adrenaline and possibly a combination of other hormones. The stickleback male fish has also been known to exhibit parental aggression thereby protecting the breeding ground and preventing the fries from being eaten up by predators using their spines as a defense mechanism [10].

Also, Catfish (*Clarias magur*) males according to Priyadarshi., *et al.* [36] exhibits aggressive mating behavior when injected with overtime and oxytocin (gonadotropic hormones) and is in close proximity to another sexually mature male. Priyadarshi., *et al.* [36] further reports that this aggression can result in fatal injuries as the male's wrestle for the rights to mate. Geist [15] lays emphasis on the use of horns by deers when they encounter rival males during breeding season or meet predators in order to contest with such rivals and choose to fight or escape such predators. Here the fight or flight hormones and testosterone are major influences causing a display of sexual aggression and anti-predatory aggression. Aggression is however different in the Dragon Lizard (*Goniocephalus*) usually camouflaging with different displays and later turning on its attacker biting fiercely, emitting a guttural hissing sound before escaping. This is an anti-predatory aggression in which adrenaline (fight or flight hormone) acts as a major influence [6].

Conclusion

Therefore, although hormones play a vital role in eliciting aggressive behaviors, from animals they are not responsible for such behaviors but play a highly influential role by causing stimulations that have great effects on the neural system which in turn prompts the exhibition of aggression in animals. In conclusion, hormones are therefore linked to aggressive displays in animals though conditioned also by many other factors and cannot independently cause an animal to act in an aggressive manner.

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Conflict of Interest

The authors all declare that they have no conflict of interest or whatsoever as regards this article.

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