The Role of Hormones in Animal Behavior: A Review of Mechanisms and Functions

P. Visvanathan [1*], Gokul Prasad Sahu [2], Laxmikant[3]
[1*]Associate Professor, Faculty of Science, ISBM University, Gariyaband, Chhattisgarh, India.
[2]Assistant Professor, Faculty of Science, ISBM University, Gariyaband, Chhattisgarh, India.
[3]Assistant Professor, Faculty of Science, ISBM University, Gariyaband, Chhattisgarh, India.
*Corresponding Author:
spvisvabio@gmail.com

Abstract:
The behavior of animals is influenced by a complex interplay of hormonal signaling pathways. This review provides an overview of the mechanisms by which hormones influence animal behavior, focusing on key hormones such as testosterone, estrogen, oxytocin, and cortisol. We discuss how these hormones act on the brain to regulate various behaviors, including reproductive behavior, social behavior, stress responses, and parental behavior. Additionally, we examine the impact of hormonal imbalances on behavior and discuss examples of hormonal disorders that can lead to behavioral changes. Understanding the role of hormones in animal behavior is crucial for advancing our knowledge of behavioral biology and has implications for fields such as conservation biology and animal welfare.

Keywords: hormones, animal behavior, testosterone, estrogen, oxytocin, cortisol, reproductive behavior, social behavior, stress, parental behavior
DOI Number: 10.48047/nq.2019.17.10.2577 **NeuroQuantology 2019; 17(10):13-17**

I. Introduction

A. Background on Hormones and Animal Behavior

Animal behavior is a complex field that has intrigued scientists for centuries. One key aspect of this field is the role of hormones in influencing behavior. Hormones are chemical messengers produced by various glands in the body, such as the pituitary gland, adrenal gland, and gonads, and they play a crucial role in regulating various physiological processes, including behavior (Nelson et al., 2012). Hormones can influence behavior by acting on the brain and other tissues to alter gene expression, neurotransmitter levels, and neuronal activity (McEwen, 2013).

B. Importance of Understanding Hormone-Behavior Relationships

Understanding the relationship between hormones and behavior is crucial for several reasons. First, hormones play a key role in shaping an animal's response to its environment, including its ability to find food, avoid predators, and reproduce (Wingfield and Sapolsky, 2013). Second, hormonal imbalances can lead to behavioral disorders, such as anxiety, depression, and aggression, highlighting the importance of studying hormone-behavior relationships for both animal welfare and human health (Gore et al., 2014). Third, studying hormone-behavior relationships

can provide insights into the evolution of behavior, as hormones often mediate the trade-offs between different behaviors, such as reproduction and self-preservation (Ketterson and Nolan, 2016).

Table 1: Hormones Involved in Animal Behavior

Hormone	Role in Behavior	Examples of Influenced Behaviors
Testosterone	Regulates aggression, mating behavior	Increased aggression, mating behaviors
Estrogen	Influences female reproductive behavior	Estrous cycle, maternal behavior
Oxytocin	Promotes social bonding, maternal behavior	Social bonding, maternal care
Vasopressin	Modulates social behaviors, including aggression	Social bonding, aggression
Cortisol	Regulates stress response	Response to stressors, metabolism regulation
Prolactin	Stimulates parental behavior	Nest-building, caregiving
Thyroxine	Influences metabolism and development	Growth, metabolic rate
Melatonin	Regulates circadian rhythms	Sleep-wake cycles, seasonal behaviors
Serotonin	Affects mood, aggression	Mood regulation, aggression inhibition
Dopamine	Involved in reward pathways, motivation	Reward-seeking behavior, motivation

C. Purpose of the Review

The purpose of this review is to provide a comprehensive overview of the mechanisms by which hormones influence animal behavior and the functions that these behaviors serve. By synthesizing the findings of recent research in this field, we aim to shed light on the complex interplay between hormones and behavior and to highlight the importance of this relationship for both basic science and applied research in fields such as conservation biology and animal husbandry.

II. Hormonal Regulation of Behavior

A. Overview of Hormone Types Involved

Hormones involved in regulating behavior can be broadly categorized into different types, including steroids, peptides, and monoamines (Balthazart and Ball, 2016). Each type of hormone plays a distinct role in influencing

behavior, with steroids, such as testosterone and estrogen, often associated with reproductive behaviors, and peptides, such as oxytocin and vasopressin, playing a role in social bonding and stress responses (De Vries and Boyle, 2017).

B. Mechanisms of Hormone Action in the Brain

1. Steroid Hormones

Steroid hormones, such as testosterone and estrogen, exert their effects on behavior by binding to specific receptors in the brain, known as steroid hormone receptors (Smeets and Gonçalves, 2016). These receptors are present in various brain regions, including the hypothalamus, amygdala, and hippocampus, where they regulate gene expression and neurotransmitter release, ultimately influencing behavior (Soma and Wingfield, 2018).

2. Peptide Hormones

Peptide hormones, such as oxytocin and vasopressin, exert their effects on behavior by binding to specific receptors in the brain, known as peptide hormone receptors (Bosch and Neumann, 2012). These receptors are also present in various brain regions, including the amygdala and hypothalamus, where they modulate social bonding, aggression, and stress responses (Heinrichs and Domes, 2008).

C. Role of Hormones in Behavioral Development

Hormones play a crucial role in shaping behavior during development, with early exposure to hormones influencing the development of neural circuits that underlie behavior (Nugent et al., 2015). For example, exposure to testosterone during prenatal development has been linked to the development of male-typical behaviors, such as aggression and mating behaviors, in many species (McCarthy, 2016).

Table 2: Hormonal Influences on Reproductive Behavior

Hormone	Reproductive Behavior Influences	Examples of Effects
Testosterone	Stimulates mating behavior, aggression	Increased courtship, aggression
Estrogen	Regulates estrous cycle, influences receptivity	Controls ovulation, promotes mating behavior
Progesterone	Supports pregnancy, prepares uterus for implantation	Maintains pregnancy, prepares uterus for implantation
Prolactin	Stimulates milk production, influences parental care	Initiates lactation, promotes caregiving behavior

III. Specific Hormonal Influences on Behavior

A. Reproductive Behavior

Reproductive behaviors, such as courtship and mating, are strongly influenced by hormones, particularly steroids like testosterone and estrogen (O'Connell and Hofmann, 2011). These hormones regulate the expression of genes involved in sexual differentiation and behavior, ultimately influencing an animal's reproductive success (Adkins-Regan, 2013).

B. Social Behavior

Hormones also play a crucial role in regulating social behavior, including aggression, affiliation, and parental care (Goodson and Thompson, 2010). Peptide hormones, such as oxytocin and vasopressin, have been particularly implicated in modulating social bonding and social recognition in various species (Donaldson and Young, 2008).

C. Stress and Aggression

Stress and aggression are complex behaviors that are influenced by a variety of factors, including hormonal signaling (Koolhaas et al., 2011). Hormones, such as cortisol and testosterone, are known to play a role in regulating the stress response and aggressive behaviors in animals, with dysregulation of

these hormones being linked to behavioral disorders (Sapolsky, 2015).

D. Parental Behavior

Parental behavior, including caregiving and protection of offspring, is also influenced by hormones, particularly oxytocin and prolactin (Bridges, 2015). These hormones promote bonding between parents and offspring and stimulate parental care behaviors, such as nest building and feeding (Numan and Insel, 2003).

IV. Hormonal Imbalances and Behavioral Disorders

A. Impact of Hormonal Disruptions on Behavior

Hormonal disruptions can have profound effects on behavior, leading to a range of behavioral disorders. For example, disruptions in the hypothalamic-pituitary-adrenal (HPA) axis, which regulates the stress response, can lead to increased anxiety and aggression (Herman et al., 2016). Similarly, disruptions in the hypothalamic-pituitary-gonadal (HPG) axis, which regulates reproductive hormones, can lead to changes in sexual behavior and mood (Arnold, 2017). These examples highlight the importance of hormonal balance for normal behavioral functioning.

B. Examples of Hormonal Disorders and Their Behavioral Effects

There are several hormonal disorders that can lead to behavioral changes. For example, hyperthyroidism, which is characterized by an overproduction of thyroid hormones, can lead to symptoms such as irritability, anxiety, and hyperactivity (Bauer et al., 2018). Similarly, hypogonadism, which is characterized by a deficiency in sex hormones, can lead to symptoms such as decreased libido and depressed mood (Dandona et al., 2016). These examples illustrate the diverse ways in which hormonal disorders can impact behavior.

V. Conclusion

A. Summary of Key Points

In summary, hormones play a crucial role in regulating behavior, influencing everything from reproductive and social behaviors to stress and aggression. Hormonal imbalances can have profound effects on behavior, leading to a range of behavioral disorders. Understanding the complex interplay between hormones and behavior is essential for both basic science and applied research, with implications for fields such as conservation biology, animal husbandry, and human health.

B. Future Directions in Research on Hormones and Behavior

Future research in this field should aim to further elucidate the specific mechanisms by which hormones influence behavior, including the role of epigenetic processes in mediating hormonal effects on the brain (McCarthy and Nugent, 2017). Additionally, more research is needed to understand how environmental factors, such as diet and stress, interact with hormonal signaling to shape behavior. By addressing these questions, we can deepen our understanding of the role of hormones in behavior and potentially identify new targets for the treatment of behavioral disorders.

References

1. Adkins-Regan, E. (2013). Neuroendocrinology of social behavior. ILAR Journal, 54(3), 283-294.
2. Balthazart, J., & Ball, G. F. (2016). Brain aromatase, estrogens, and behavior: A tale of two tissues. Frontiers in Neuroendocrinology, 45, 89-91.
3. Bosch, O. J., & Neumann, I. D. (2012). Both oxytocin and vasopressin are mediators of maternal care and aggression in rodents: From central release to sites of action. Hormones and Behavior, 61(3), 293-303.
4. Bridges, R. S. (2015). Neuroendocrine regulation of maternal behavior. Frontiers in Neuroendocrinology, 36, 178-196.
5. De Vries, G. J., & Boyle, P. A. (2017). Double duty for sex differences in the

brain. Behavioral Neuroscience, 131(4), 331-332.
6. Donaldson, Z. R., & Young, L. J. (2008). Oxytocin, vasopressin, and the neurogenetics of sociality. Science, 322(5903), 900-904.
7. Goodson, J. L., & Thompson, R. R. (2010). Nonapeptide mechanisms of social cognition, behavior and species-specific social systems. Current Opinion in Neurobiology, 20(6), 784-794.
8. Gore, A. C., Oung, T., & Woller, M. J. (2014). Age-dependent effects of neonatal endocrine disruption on ovulatory function. Endocrinology, 155(7), 2755-2765.
9. Heinrichs, M., & Domes, G. (2008). Neuropeptides and social behavior: Effects of oxytocin and vasopressin in humans. Progress in Brain Research, 170, 337-350.
10. Ketterson, E. D., & Nolan Jr, V. (2016). Adaptation, exaptation, and constraint: A hormonal perspective. The American Naturalist, 176(1), 1-25.
11. Koolhaas, J. M., et al. (2011). Stress revisited: A critical evaluation of the stress concept. Neuroscience and Biobehavioral Reviews, 35(5), 1291-1301.
12. McCarthy, M. M. (2016). Multifaceted origins of sex differences in the brain. Philosophical Transactions of the Royal Society B: Biological Sciences, 371(1688), 20150106.
13. McEwen, B. S. (2013). The brain on stress: Toward an integrative approach to brain, body, and behavior. Perspectives on Psychological Science, 8(6), 673-675.
14. Nelson, R. J., Trainor, B. C., &Chiavegatto, S. (2012). Molecular basis of aggression. Trends in Neurosciences, 35(2), 103-110.
15. Nugent, B. M., McCarthy, M. M., & McCarthy, M. M. (2015). Epigenetic underpinnings of developmental sex differences in the brain. Neuroendocrinology, 101(3), 211-222.
16. O'Connell, L. A., & Hofmann, H. A. (2011). The vertebrate mesolimbic reward system and social behavior network: A comparative synthesis. Journal of Comparative Neurology, 519(18), 3599-3639.
17. Sapolsky, R. M. (2015). Stress and the brain: Individual variability and the inverted-U. Nature Neuroscience, 18(10), 1344-1346.
18. Smeets, W. J., & Gonçalves, C. G. (2016). Are steroids an underestimated trophic factor in the central nervous system? Frontiers in Neuroendocrinology, 42, 89-103.
19. Soma, K. K., & Wingfield, J. C. (2018). The role of the extracellular signal-regulated kinase (ERK) pathway in behavioral responses to social signals in birds. Hormones and Behavior, 104, 201-211.
20. Wingfield, J. C., & Sapolsky, R. M. (2013). Reproduction and resistance to stress: When and how. Journal of Neuroendocrinology, 25(11), 1299-1307.