National Journal of Medical and Allied Sciences
[ISSN Online: 2319 – 6335, Print: 2393 – 9192|Review article |Open Access]
Website:-www.njmsonline.org

PARENTING HABITS IN BIRDS AND IT'S PHYSIOLOGICAL BASIS

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ABSTRACT

Parental care of offspring needs a huge investment either by father or mother or both. Most common type of care in animal kingdom is single parent care. Even in mammals, only 3-5% invest in bi-parental care . In contrary, bi-parental care is the most common form of rearing offspring in birds as seen in about 85% species . The ‘good parent hypothesis’ states that birds can invest more energy towards their own survival rate by choosing an ideal mate thus investing more towards a bi-parental care and rearing stronger offspring than those cared by single parent. Female birds are generally more likely to care for the offspring of males that spend more time building nest and build more elaborate nests. As a consequence, the reproductive success of males tends to increase with nest size and building behaviour . This article tries to sum up the important views proposed by various researchers over last thirty years time and explain it in the light of recent advances in physiology.

Keywords: Birds, parental care, physiology

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INTRODUCTION

All 9000 species of birds lay eggs and they vary in size from the tiny 0.2 gram eggs of humming birds to the 9 kg eggs of the extinct elephant bird. Mother bird dispenses the fertile eggs as soon as the shell is formed to retain mobility. These apparently fragile looking eggs are actually engineering marvels - the surface resembles an arched bridge and for the same reason it can withstand an incubating mom’s weight. It takes 26 pounds of pressure to break a swan’s egg and 120 pounds to smash the egg of an ostrich. These protein-rich eggs are a prize to the predators. So the birds have developed innumerable ways of building nests for safe hatching and a male bird’s suitability as a pair depends on it’s skill in building nests [1-5].

It is presumed that the earliest form of parental care was mono-parental male care [6,7,8]; the next stage of evolution replaced this with bi-parental care with a few exceptions.

Ligon and Vehrencamp suggested that male incubation existed first and later gave way to shared and finally female only incubation [9,10].

Between 1975 to early 2005 Andrew Cockburn thoroughly compiled articles about parenting behaviour in almost all the species of birds. He estimated the prevalence of six distinct modes of care: use of geothermal heat to incubate eggs, brood parasitism, male only care, female only care, bi-parental care and cooperative breeding [2].

MATERIAL AND METHODS

An attempt was made to explain the physiological basis of parenting behaviour in animal kingdom as a whole. Search strategy comprised of using relevant search terms from databases and internet sources like Google Scholar, DOAJ, Pubmed, etc.. Ethical approval was not required as it was a secondary study.

RESULTS

In the following section various modes of care will be discussed and an attempt will be made to explain the physiological basis of parenting behaviour in animal kingdom as a whole.

Methods of providing care in birds:

Female only care and cooperative breeding are known to occur in 8 and 9 of the bird species respectively. Bi-parental care by a bonded male and female is the most common pattern of care seen in 75−81% of the species. 1% of the species escape parental care through brood parasitism or the use of geothermal heat and another 1% of all species have male only care. Two of the most widely cited statistics concerning sociability and parental care in birds are the estimates by Lack [11] that 92% of them form pair bonds and Brown [12] reports that 2.5% of all birds breed cooperatively. Lack explicitly emphasized that pair bonds and biparental care are not synonymous.

Parental care is dynamic and either male or female can abandon care to the other at various stages of the nesting cycle. The transitions in many families are associated with it being either *frugivory* (fruit eating) or *nectarivory* (nectar eating). In tropics, availability of fruits may be patchy and short term; hence the males guard the fruiting or flowering trees and the females traverse to gather those fruits or nectar leading to 'female only care'. This is known as the "Hotspot hypothesis" which was proposed by Bradbury [13]. The "Constrained female hypothesis" posits that females would rather prefer low quality but abundantly available local food to feed the chicks and hence they ignore the male help and choose freely among males for good genes [14,15] . In insectivorous species, males are of premium help in obtaining good insects. But if the chicks grow slowly and have low metabolism, females become the sole care giver. In marshlands rich with abundant insects, females alone or in groups can take care of the young ones. In these two cases females prefer good genes rather than parenting skill and huge aggregations of many females at one spot can lead to polygyny and evolution of new species [16]. Another reason for avoiding male help might be due to the fact that presence of male bird near the nest attracts predators especially in rain forests. Cooperative breeding is mostly seen in those species who forage at sea for food but breed on the land. Necessity of prolonged departures to forage enforces constant nest attendance sometimes by the additional birds. In Adelie penguins, non-breeders or even failed breeders improve survival of chicks by huddling, herding into shelter and by defending chicks against skuas (predatory seabirds). Additional attendants also have been seen in many species of tern. Brown skuas are true cooperative breeders; males live the early part of their lives in clubs in the low quality centres of the islands where breeding occurs. Eventually, they form coalitions to drive off territory owners. Although there is a single chick, mating is egalitarian and all coalition males probably contribute to paternity over many years. Cooperation is well known to be more common among residents than migrants. A very large proportion (13%) of all passerines (sparrow, song-bird or finches) are cooperative breeders. A very unusual cooperation in breeding has evolved between the small red-breasted geese of Siberian tundra and the pegerine falcons. Falcons are fierce bird of prey but they don't prey on geese. So these geese nest in tight knots around the falcon's nests. Arctic foxes don't dare to go close to fierce falcons and thus the goose chicks stay safe. On the other hand loud alarm calls of the geese alert the falcons to protect their own chicks [5].

Brood parasitism is the most cunning method of bypassing nest building and parenthood. Cuckoos are the most common example and they parasitize the nests of a large variety of bird species and carefully mimic the colour and pattern of their own eggs to match that of their hosts. Each female cuckoo specializes in one particular host species. It remains profoundly mysterious as to how the cuckoo manages to lay eggs designed to accurately imitate the host's eggs [5].

Polyandry care occurs in roughly 9% of bird species (approximately 852 species) [2]. The two forms of polyandry are sequential and simultaneous polyandry. In sequential polyandry, females will first mate with one male and raise the offspring for a short period of time. Then they will mate with another male and care for that clutch resulting in more genetic diversity and quantity of the offspring per season. Females never incubate offspring alone unless the male has been killed. Some examples of birds who practice sequential polyandry include spotted sandpipers and red-necked phalaropes. Temminck's stint, little stint, mountain plover, and sanderling are very similar because the females lay a clutch of eggs and the males incubate them. A second clutch is laid that the female incubates herself.

Care needed by the chicks vary widely across the species. Some chicks need constant passive feeding for 5−15 days while a chick of ancient murrelet (small seabird) is taken to the sea almost as soon as it is born. But the most self-sufficient bird on earth is the cuckoo-duck chick of Argentina which spreads it's wings just one day after it's mom drops the egg in the nest of an unsuspecting brown hooded gull. Chicks of hens and ducks grow within the egg and hatch out with fully formed eyes and feathers and can move freely. The chicks of the American white pelican tell their parents when they are too hot or too cold by giving loud and clear distress calls from inside the eggs and the parents adjust their position accordingly [5]. A new research by a team from the department of Zoology, University of Cambridge has found that mother bids communicate with their developing chicks before they even hatch, by changing conditions in the egg. Canary mothers leave a message for their chicks about the life they will face after birth; in response, nestling adjust their begging behaviour! If chicks get a message that they will be reared by generous parents then they beg more vigorously for food after hatching. But chicks that are destined to be raised by meaner parents end up being much less demanding.

By attending to messages in the egg, nestlings gain weight more rapidly because they match their demands to the parents' supply of food, and can avoid either begging too little or wasting effort on unrewarded begging [17].

Factors affecting parental care:

i) *Male-Female ratio :* With an increase in available mates in some birds (e.g rock sparrow) female desertion rate increases leading to more mono-parental care. When female rock sparrows were exposed to an abundant amount of male mates, approximately 50% of the females deserted their first nest when the hatchlings were on average 14.3 days old. The fathers successfully took over all parental duties [3].

ii) *Effect of food on gender ratio:* A study on Zebra finches showed that sex of an egg depended on the amount of nutrients available to the female, not on the male's sperm! Female offspring need more nourishment than males to survive because egg production is metabolically exhaustive and nourishment draining process. Those zebra finches who were fed a lower quality diet, laid eggs that were lighter and less nutrient-rich which produced sons and those fed a higher quality diet produced bigger and more nutrient-rich eggs which produced daughters.

In black-backed gull (Larus fuscus) females which were adequately fed and had higher body condition produced eggs with a lower level of androgens (such as testosterone) [18]. This suggests that females with a lower body condition (which correlates with poor conditions) presumably increase chick quality or chick survival by depositing larger quantities of androgen in their eggs. Thus the birds increase the survivability rate of their species by increasing yolk steroids to fight hostile conditions which can be seen as 'pre-birth parental care' adaptation [19].

iii) *Timing & Temperature of reproduction:* Most birds reproduce earlier if spring comes earlier. Visser [20] undertook a 6-year-long experiment in Great Tits (Parus major) and found that if spring came 3 weeks early birds reproduced early due to earlier development of breeding plumage and other cues. He observed this both in wild and captive birds. Higher early spring temperature also led to higher levels of parental care stemming from more commitment. Because parents find mates to reproduce earlier, it can also be seen as a 'pre-birth parental care adaptation' due to less desertion [3].

iv) *Role of maternal antibody:* Yolk in the eggs of birds contain a maternal antibody IgY which gives protection to the growing chicks against disease. The carotenoids in egg yolk are infused with Vitamin E and anti-oxidants which prevent destruction of IgY and also foetal tissues; this also can be seen as a form of 'pre-birth parental care' [21].

v) *Ornamental cues and parental care:* There is a positive correlation between ornamental cues and parental care as seen in Iberian rock sparrows

(Vincenta garcia navas). Males show greater effort and visit their offsprings more frequently if their females have a larger yellow chest patches [3].

But this good parent hypothesis is challenged in other species; in common yellowthroats of USA, no positive correlation was seen in males having black face mask or yellow ventral patch as they didn't put much investment towards their young ones and their females were also not affected by these ornamental cues. C. R. Freeman-Gallant of the department of biology at Skidmore college, NY, USA concluded that, larger ornamental cues on males rather led them to more male-male competition to find mates for future reproductive success or holding territories. In Pied flycatchers, younger males with large badge size get hold of territory by competing with other males and provide less parental care while females adjust their parental investment to accommodate the male [22].

Discussion on the physiological basis of parenting habits:

In most of the birds species, parents invest profoundly in their offspring as a mutual effort, making a majority of them socially monogamous for the duration of the breeding season. But DNA fingerprinting has revealed that as many as a fifth of the eggs produced by female birds, believed to be monogamous, had not been sired by their regular partners. Also there is evidence for jealousy between competing females for a particular male and even divorce among mates who fail to rear offsprings! The superb fairy wren of Southern Australia is the most promiscuous bird in the world. Both males and females have multiple partners and scientists have concluded that these "extra-marital" liasons among superb fairy wren are largely motivated by wanting to increase their chances at successful breeding [5].

A variety of social, environmental, physiological, and experiential factors influence parental behaviour, but the most important hormonal factor is elevated prolactin (PRL) which is often reinforced by previous elevation of the sex steroids. Prolactin secretion and parental behaviour appear to be mutually reinforcing as contact with eggs or chicks often elevates PRL. Elevated testosterone and paternal behaviour are generally mutually exclusive. Environmental stress, which elevates corticosterone and decreases PRL, can decrease parental behaviour while elevating survival behaviours in adults [23]. Progesterone can also interact with testosterone in modulating male behaviour. A study in 'challenged' (male-male competition) male rufus horneros (oven bird) showed that their progesterone level was high during mating period and testosterone was low during parental care though the ratio of progesterone to testosterone was similar in both the periods but the ratio was higher than that in the control (non-challenged) birds. The experiment showed that territorial aggression triggered hormonal pathways differently depending on the stage of the breeding cycle [24].

Fathering behaviour in mammals is rare and only 3−5% of mammals exhibit biparental care whereas it's the most common in birds. RNA sequencing identified a group of genes in male prairie voles (field mice) located in their medial pre-optic area (MPOA) which are involved in various processes like immune function, metabolism, synaptic plasticity and remodelling of dendritic spines. This study showed how gene expression changed across the transition to fatherhood and affected the male parenting behaviour with respect to different social experiences [1].

Lastly, all animals have a generic pattern of basic instinctive behaviours but their behaviour demands changes as per the change in the internal and external environments. Social learning of a juvenile bird initially happens by observing parents (vertical transmission) and subsequently by observing others (horizontal/oblique transmission). Early social experience with parents affect foraging decisions but later social environments lead the juveniles to modify their behaviour [25]. In the chick, a common generic pattern underlies both hatching and walking but modulatory inputs can essentially change all the functional components of a single anatomically defined network. Some of the probable mechanisms of these neuromodulations are i) serotonin induced change in K-current that modulates membrane potential and ii) change in synaptic efficacy by regulating the amount of neurotransmitter release thus affecting Excitatory post-synaptic potentials (EPSPs) and Inhibitory post-synaptic potentials (IPSPs) [26]. Another study on female Nicrophorus vespilloides (Burying beetle) found upregulation of seven neuropeptides especially two kinins (tachykinin and sulphakinin) during parenting which may explain the evolution of social and parental skill in animal kingdom as a whole [27].

The study of parenting habits is absolutely fascinating. The most intriguing question is what makes a good parent? Is it biological nature or experience or both? It is important to understand the neuro-hormonal basis of the parenting behaviour which has mostly been studied in animal and avian models. In mammals, the most commonly studied species are rats, mice and rhesus monkeys. These studies in animal models have yielded a rich source of hypotheses for human studies.

The neurobiology of mothering has been linked to the level of falling progesterone and rising oestrogen, prolactin and most importantly oxytocin which act in the medial pre-optic area (MPOA) to make pup stimuli salient to the new mother which results in release of dopamine and involvement of mesolimbo-cortical 'motivation system' [28, 29].

The neurobiology of fathering is far less studied than the neurobiology of mothering. The most consistent finding from the animal literature is that testosterone is usually antithetical to male parenting [30]. Testosterone, on the other hand, decreases in men who become involved fathers [31].

Parents in modern society face tremendous challenge to provide quality childcare that increasingly strain sensitive nurturing of the child. There is mounting evidence that the very structure of the human brain is altered by the cognitive challenges inherent in learning how to parent [31].

CONCLUSION:

In future, the great variety of parental caregiving systems displayed by animals should be thoroughly explored and most importantly, cross-talk between animal and human subjects research should be promoted.

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Conflicts of Interest: Nil Source of Funding: Nil

Citation: Mukherjee SS. Parenting habits in birds and it's physiological basis' National Journal of Medical and Allied Sciences 2021; 10(1): Online first

Date of Submission: 03-09-2020
Date of Acceptance: 12-09-2020