Evaluation of the Physiological Specialization of the Hearing Organs of Posthatch Chicken Rearing at Different Environmental Circumstances.

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Abstract: *Middle ear and internal ear correlates with neurophysiological responses to a wide range of sound frequencies for species of the G.domesticus representing generalized, intermediate, and specialized anatomical conditions. Neurophysiological data were recorded from 2 specimens; first, Poultry farm (rearing in captivity) and second domestic post hatch (P) chicken (rearing in freely, stages, P40-P45). Functional and anatomical parameters involved in the process of frequency selectivity were correlated with the physiological data to assess the effects of different degrees of anatomical specialization on acoustic sensation. Ears were the anatomical specializations show greater auditory sensitivity in domestic chicken than poultry chicken. The natural history of the G.domesticus, particularly the kinds of predators, habitat and environmental circumstances is reviewed and used to explain the significant of the stages of auditory specialization in the studied. Evaluate the prevailing hypothesis that these sensory specializations increase the capacity of this animal to survive in open environmental circumstances by detecting and evading predators. The anatomy of the middle ear and internal ear of each five specimens was also studied. Thus, data on the entire spectrum of the anatomical and physiological of the middle ear, tympanic membrane, and inner ear provide an evolutionary sequence. Certain anatomical parameters of the tympanic membrane show the stages of specialization analogous to that of features of the middle ear and the inner ear. The anatomical, physiological alteration and role of these elements are considered. A very high correlation exists for the degree of specialization aridity of habitat and other circumstances. Therefore, specialization increases with alteration of aridity and other environmental variation. This increased specialization of the middle and inner ear may result from more efficient sensation in open environments. Auditory sharpness for a broad range of low-frequency sounds enhanced by tympanic membrane specialization is, therefore, more advantageous here. The spikes rate (6 ± 1.5sp/s) of greatest sensory sensitivity appears to according to the resonant frequencies of the different components of the tympanic membrane transformer and cavity.*

Key Words: *tympanic membrane, Phasianidae, physiological, auditory neurons, Gallus domesticus.*

1. INTRODUCTION:

Chicken of the family Phasianidae, class Aves, have the greater numbers of species of all birds that inhabitant at the open area. The chicken was rearing at free circumstances (domestic chicken), and closed conditions (poultry farm) Considerable variation typifies the middle and inner ear of the living Chicken. Domestic chicken is more specialized about those that inhabit in the captivity. Physiological responses of ears and the natural history of living species representing generalized, intermediate and specialized conditions were studied to: (1) provide numerical quantification of the anatomical parameters effective in producing auditory responses to sound in air; (2) correlate these anatomical parameters with physiological sensitivity to assess the effects of degree of anatomical specialization on hearing; (3) provide suggestions concerning the evolutionary sequence(s) by which specialized ears may have been derived from generalized ears in the G.domesticus; (4) evaluate the hypotheses which have been advanced to account for the specialized auditory structures characteristic of many captive and free habitation chick.

2. MATERIALS AND METHODS:

Many of the procedures used in the present study were described previously and in some instances in more detail. Staging followed the conventions outlined by Hamburger and Hamilton (1951).

Chickens (*Gallus domesticus*) were procured from a local poultry farm. They were reared different environmental conditions for four weeks one group was reared in captivity and the second group in freely. They were fed on whole grains such as corn barley, oats, and wheat, once in 24 hrs. Animal included in this study were bred in a closed colony maintained. Chickens were studied at equivalent days from P40 to P45 (post hatch). The animal was placed on a sound-attenuating booth. For P40 to P45 mean beak and toe lengths were 1.5 ± 5 mm and 02 ± 5 mm respectively, corresponding to stages 43-45 of Hamburger and Hamilton (1951)

Posthatch birds were anesthetized using by chloroform (0.5 ml/kg) and given time to time supplements of chloroform (0.5 ml) to maintain anesthetic level. The mean heart rate in the animal was 285 ± 24 bpm. Brain temperatures of P40 animal were maintained at a mean of 35 ± 2.39°C, whereas in P45 animals it was 37.2 ± 1.6°C

The lungs were perfused with an oxygen-enriched, humidified warm air/CO2 mixture as described in detail elsewhere (Nazareth and Jones 1998). In all cases, the work was carried out in adherence to The Guiding Principles in the Care and Use of Animals Committee.

In all animals, the beaks were embedded in plaster to stabilize the head in a position with beak down. The Naso-occipital axis of the head was adjusted nearly 30° off vertical to the right and posterior. A small opening was made through the bony plate overlying the recesses scala tympani, and the periosteal lining of the labyrinth was opened to expose the underlying perilymph. Glass micropipettes were filled with 0.5 M KCl (pH 7.4). The electrometer (WPI Intra) provided for current injection and periodic impedance checks (20–8 MΩ). Reference (neck) and ground (thorax for post hatch birds, extraembryonic fluid for embryos) electrodes were chloride-silver wire. A Burleigh Inchworm stepper was used to position microelectrodes. Recordings were made of isolated single auditory neurons and primary afferent neurons. Auditory neural activity was amplified, led to a window discriminator, a spike timer, and an analog tape recorder for storage and off-line analysis.

Airborne sound stimuli were delivered using a calibrated Etymotic ER2 earphone inserted and sealed into place in the left external auditory meatus (EAM). This method of sound presentation is referred to as "airborne" stimulation throughout this report. Sound levels were measured in dB SPL the maximum stimulus level available was about 90 dB SPL (footplate stimulation). A calibrated probe tube microphone (Etymotic ER7) was sealed in the EAM near the tympanic membrane. Clicks, pure tones, noise, or pure-tone bursts were used as stimuli to determine whether individual cells responded to sound. Pure-tone bursts (i.e., 5-ms onset/offset ramp, a range of plateau durations from 20 to 80 ms, 50 to 5,000 Hz) were used to estimate the frequency eliciting the maximum level of firing. In most cases, an automated procedure [termed quick tune (QT)] was used to make a rapid estimate of the frequency producing a maximum response. The response of the cell was recorded continuously during the presentation of a constant-amplitude sinewave frequency sweep (generally 100 to 2,000 Hz). The frequency generating the highest spike rates was defined as the "best frequency" and designated as CF.

A computerized threshold-tracking procedure was completed to obtain an FTC (frequency tuning curves). Response threshold was determined for each frequency [typically 60 frequencies from 100 to 2,000 Hz; tone bursts: 5-ms rise/fall time; plateau of 40 ms (hatchlings)]. The number of spikes that occurred during the stimulus plateau and the number occurring during an equal period of silence (i.e., no stimulus) was subtracted. A difference of two spikes was set as the criterion for response threshold at each frequency. The CF for each FTC was documented and defined as the frequency corresponding to the lowest threshold level.

Poststimulus time histograms (PSTHs) were also generated. The onset time for each spike was logged during a specified period (usually 50 ms) immediately after the onset of a tone burst stimulus. This was repeated to accumulate spike counts in time bins (commonly 1–5 ms). When possible, a rate–intensity matrix was determined for a cell using 50 frequencies and 12 stimulus levels, with each combination presented in random order. All FTCs and PSTHs were measured online and spike timing recorded at a conversion rate of 1μs per point. Spontaneous discharge activity was recorded on tape and analyzed off-line.

Burst Index (BI): BI was calculated only for those records with more spikes. The intervals in each spike record were ranked from longest to shortest. The longest intervals were then used to calculate BI. The four longest intervals were used for records containing 10 to 75 spikes. If more than 75 spikes were recorded, then the number of longest intervals used was calculated as 6% of the total number of spikes (truncated to an integer). The BI was then calculated as follows:

BI = A × B
A = total time of the longest interval/ total sample time
B = mean interval length of the longest intervals/ total number of intervals
The first component (A) of the BI equation reflects the proportion of time that a cell spent in long silent periods. The second component (B) provides an adjustment of the BI for the relative amount of activity present during discharge bursts such that the greater the contrast between silent and active periods, the greater was the BI. BIs above 1.0 signal the presence of bursting, and the greater the BI, the more pronounced is the bursting (Jones and Jones 2000; Jones et al. 2001)

3. RESULT:
Examination of figures Fig-1 and 2 reveals a striking dissimilarity in the disposition of the overall curves of auditory responses of the animals studied by electrophysiological. Studied on the captive and domestic animal, the peak of maximum sensitivity occurs between 2500 and 3000 Hz. A second major peak, usually of slightly less magnitude, exists between 1500 and 2000 Hz. These two peaks are separated by a pronounced drop in sensitivity at either 2000 or 1800 Hz. The third major peak between 1500 and 1900 Hz does not seem to be present in the captive animal. It shows a minor peak at 1800 to 1500 Hz followed by a drop at 2000 Hz, but freely rearing animal to display a graded rise in responses from 1600 to 2000 Hz. A minor peak occurs at 1000 to 500 Hz in domestic chicken, but this minor and last peak do not occur in poultry farm chicken. The major impression obtained by plotting the sensitivity curves of all species on a single graph is that increasing anatomical specialization in the inner and middle ear, results in a concomitant increase in the potential cochlear response (sensitivity) over the range of frequencies tested.

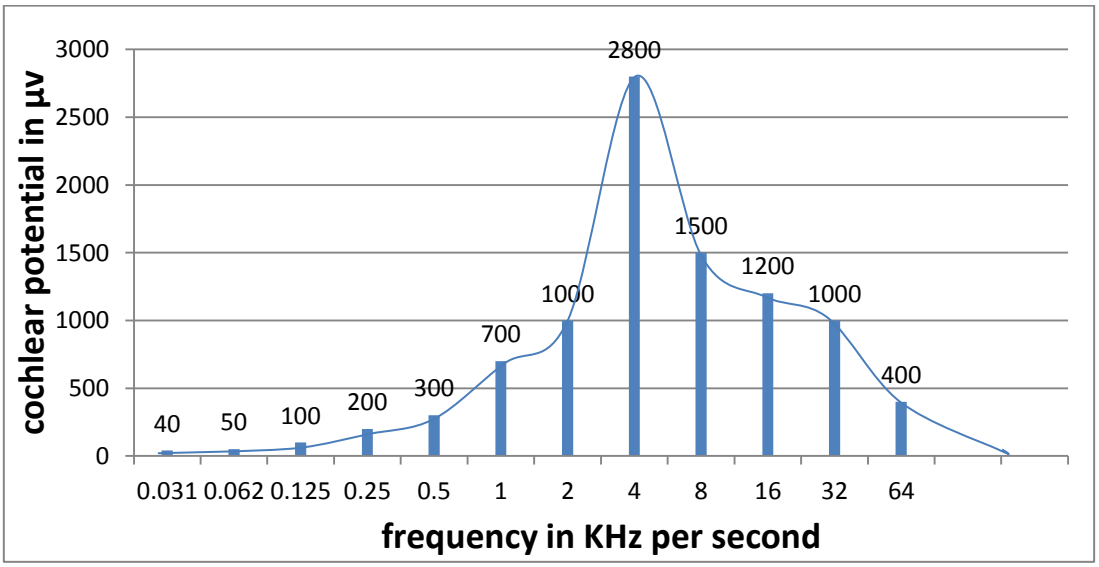

Fig.1

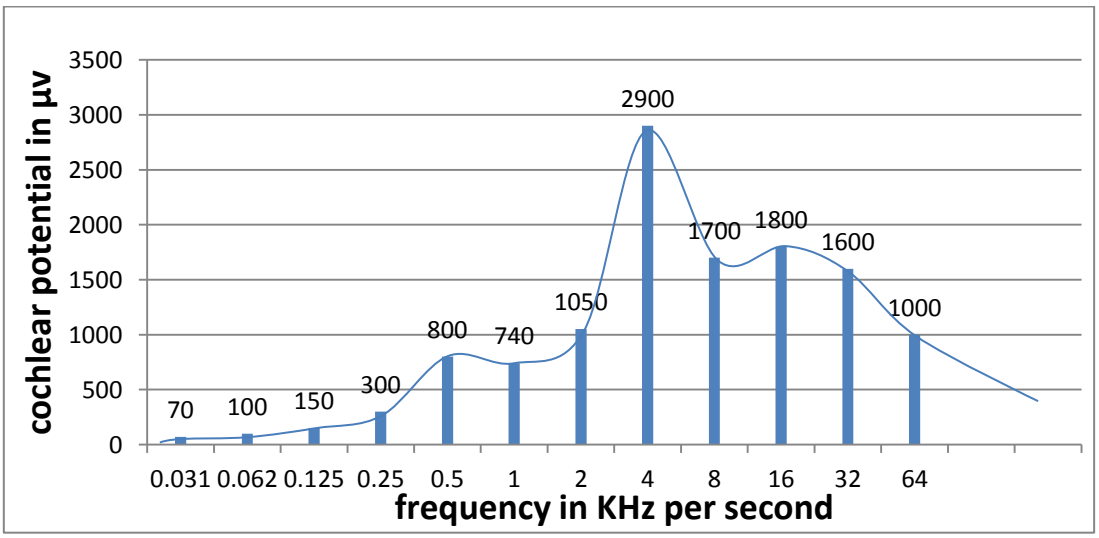

Fig. 2

Fig-1 and **Fig-2** Auditory sensitivity curves at 80 dB for the animals respectively rearing in poultry (captivity) and domestic (freely rearing) chicken. Horizontal lines with bar indicate one standard deviation.
Altogether our results are consistent with the hypothesis that a very high correlation for aridity, open environment specialization, thus anatomical and physiological specialization increases according to environmental specialization, because we were observed that the anatomy of the tympanic membrane and auditory response of animal that they were reared in captivity have less specialized than domestic chicken. (See **Fig A, B** and **1, 2**).

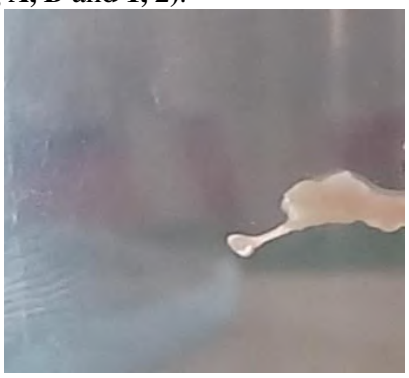

Fig-A

Fig-B

Schematic representation the anatomy of the tympanic membrane; Fig-A and Fig-B respectively represent the organ of poultry chicken and freely rearing chicken; anatomical and physiologically Tympanic membrane quasi-developed of poultry chicken than domestic chicken.

In summary, details concerning predators of and degree of predation on the especially in the open place, are scarce and the role of predation in the biology of this animal is best only suggestive. Very little is known concerning mammalian and reptilian predators of this animal and information presently available indicate that mongoose and cat prey extensively on them. Reports of mongoose predation virtually cover the range of the chicken, but none provide the information necessary to evaluate critically the degree to which mongoose prey on chicken, especially in open situations. The data provide some tantalizing bits of information, which are suggestive that domestic chicken ear specializations may be necessary on predator and scarce avoidance. In the domestic chicken the tympanic volume large than poultry chicken thus the sensitivity can increase with increasing the volume and duct of the tympanic membrane.

4. DISCUSSION:

An increased mapping constant for high frequencies as compared to low frequencies has also been described for different mammals (Ehret, 1977; Liberman, 1982a; Wright, 1984), chicken (Manley et al., 1987a) and the bobtail lizard (Manley et al., 1988a). It seems to be a general feature of vertebrate hearing organs which extended their high-frequency hearing range above 1-2 kHz by an elongation of the sensory epithelium.
Rubel and Rebillard (1981) provided evidence that the collective response of the auditory nerve in the E17–E19 embryo exhibited frequency tuning characteristics. Studies of the tuning characteristics of individual ganglion neurons in the late chicken embryo (E18 and E19, stages 43 and 44) also demonstrated that most cells produced frequency tuning curves (FTCs) comparable to those found in mature animals (Jones and Jones 1995a,b).
In the present study, by tracing the peripheral origin of functionally characterized cochlear and tympanic membrane, it was found that the rearing independently and captivity have some structural and functionally dissimilarities of their hearing organs. A varying degree of differentiation of receptive hair cells over the width of the sensory epithelium within the hearing organ is found in the animals. The thresholds of afferents increase with distance of the related receptive hair cells from the neural side of the papilla and cover a range of more than 60 dB within the area of the tympanic membrane. Based on the findings we can suggest that environmental and other parameters are responsible for the physiological and morphological alteration of the inner and middle ear,

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