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VARIATIONS IN THE STRUCTURE OF THE PEEP VOCALIZATION OF FEMALE DOMESTIC CHICKS (*GALLUS GALLUS DOMESTICUS*) ON DAYS FIVE AND SIX POST-HATCHING

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ABSTRACT: Domestic chicks (*Gallus gallus domesticus*) were reared in pairs from day three post-hatching. On the fifth day of life, a chick was separated from its brood mate and 30 secs. later the chicks' vocalizations were recorded for five minutes. The recordings were analysed using Canary 1.1 sound analysis system running on Mac II vx. Seven acoustic parameters of the peep vocalizations of female chicks were measured (duration (msec), maximum frequency (kHz), minimum frequency (kHz), difference between maximum and minimum frequency (kHz), peak frequency (kHz), energy (watts) and average power (joules)). During separation chicks produced peep calls that differed in structure. In total, 12 female chicks' vocalizations were examined and seven chicks produced three distinct peeps . These were classified as short, medium and long. Three calls of each type for each chick were examined. Short peeps have a narrow frequency range and short duration, medium peeps have a wider frequency range, longer duration and a short upper inversion preceding the descending frequency. Long peeps have the widest frequency range, the longest duration and have the most complex structure. The main finding of this study is that the chick of the domestic fowl can produce three distinct types of peep call.

Adult domestic fowl (*Gallus gallus domesticus*) produce approximately 24 different vocalizations (Collias, 1987). The chick of the domestic fowl produces two main vocalizations: twitters (pleasure notes) and peeps (distress calls). They also produce the waning bout (Andrew, 1963), shriek (fear note), trill (fear trill) (Andrew, 1964; Collias and Joos, 1953) and the pleasure trill (Collias, 1987). Twitters

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swing upwards in pitch while peeps are characterised by a single descending frequency limb (Andrew, 1963, 1964; Collias, 1987; Collias and Joos, 1953).

Wood-Gush (1971) reviewed several studies using spectrogram analysis of chick vocalizations and pointed out that it is not always clear which calls (as described by different authors) are the same. Different names can be given to the same call and the same name can be given to calls that differ in structure. For example the 'Le cri d'appel du Poussin isolé' of Guyomarc'h (1962), the distress call of Collias and Joos (1953) and the peeps of Andrew (1964) are classified by Wood-Gush (1971, p. 28-29) as being the same call, yet he points out that the spectrograms presented by these researchers show differences in structure. 'Le cri d'appel de Poussin isolé' has a wider frequency range than the other peep calls and a more complex structure, the distress call of Collias and Joos (1953)and the peep of Andrew (1964) both have an intermediate and short frequency ranges, the structure of the calls is not as complex as that of the call of Guyomarc'h. Wood-Gush (1971) emphasised the need for a more objective and detailed description of the calls and of the stimulus situation in which they occur. Apart from a detailed sonograph-based analysis of the maternal calls of the broody hen (Kent, 1989, 1993), little attention has been given to a detailed analysis of the structure, or development of vocalizations in the domestic fowl.

The purpose of this paper is to examine in detail three different types of peep vocalization of the five to six day-old domestic chick. At this age the distance between the broody hen and her chicks in the natural environment increases sharply (Workman and Andrew, 1989) and their vocal interactions (Evans, 1975) become more important. Further, it has been shown that following separation from a companion, chicks produced more peeps on day 7 than on day 3 post-hatching (Kaufman and Hinde, 1961).

METHOD

Subjects

Sixteen brown leghorn chicks from two batches of eggs (Batch A: 1 male, 3 females; Batch B: 3 males, 9 females) were reared in pairs from day 3 post-hatching. The four males were eliminated from the statistical analysis. Thus, 12 female chicks were used.

Procedure

From hatching to day three post-hatching, chicks were group reared with their hatch mates. Then they were randomly selected and placed in pairs in wooden rearing pens (59 cm x 60 cm x 44 cm high) with a wire mesh roof, and a front door that slid upwards. The floor of each pen was covered with chopped straw, food and water was available at all times. The rearing pens were maintained in a house (488 cm x 423 cm) with a 250 watt infra red heating light suspended above each rearing pen. Each chick had an individually coloured leg ring.

Testing began on the fifth day post-hatching (48 hrs. after being placed in the rearing pen). A pair of chicks in their rearing pen was first moved to a wood panelled room, with a 250 watt infra red light positioned over the pen to maintain temperature stability. The chicks were then removed from the rearing pen and placed in a covered holding box for 5 minutes. The holding box was removed from the testing room to ensure that the chicks were out of each others hearing range while recording took place. One of the chicks was then returned to the rearing pen and 30 seconds later a 5 minute recording session began using an ITT SL 520 tape recorder and VIVANCO unidirectional microphone suspended approximately 10 cm above the roof of the box. Following the test period the chick was placed back in the holding box for five minutes after which, the second chick was tested. This procedure was repeated on day six with the testing order reversed. With Batch B the procedure was slightly different with one chick being removed from the rearing pen and 30 seconds later the 5 minute recording session began with the remaining chick. Following recording the two chicks were placed back in the rearing pen for five minutes and the procedure was repeated with the second chick being recorded. This procedure was repeated on day six with the testing order reversed. An observer was situated behind a wooden screen with a 5 cm x 26 cm slot which allowed observation of the chicks with minimal interference.

Measures

The taped recordings of the peeps vocalizations were transferred to a Mac II vx computer and analysed using the Canary 1.1 sound analysis program (The Cornell Bioacoustics Workstation) (Charif et al. 1993; for review see Wilkinson, 1994). All spectrograms were analysed with a filter bandwidth set at 352.94 Hz (see Fig. 1).

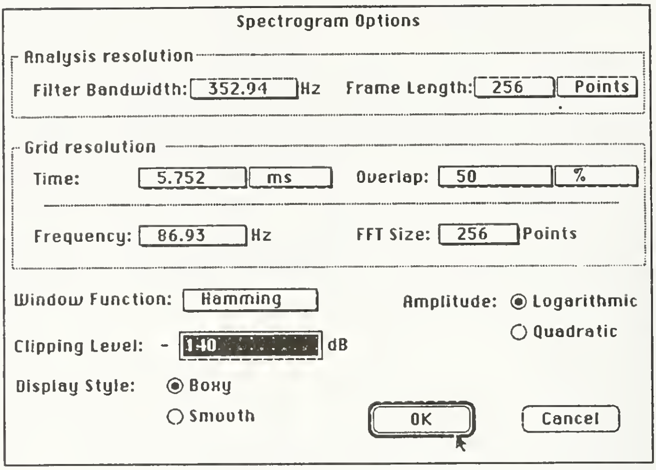

Figure 1. The Canary 1.1 spectrogram options window as used in this study.

Seven chicks produced three peep type calls (short, medium and long) and these calls resemble the calls reviewed by Wood-Gush (1971). The following seven parameters were measured for each of the three peeps recorded:

1. Duration (msec.)
2. Maximum Frequency (kHz)
3. Minimum Frequency (kHz)
4. Difference between Max. and Min Frequency (kHz)
5. Peak Frequency (kHz)
6. Energy (watts)
7. Average Power (joules)

Parameters [1-5] describe the structure of the call. Peak frequency refers to the frequency with the highest amplitude. Parameters 6 and 7 give details of energy use. The latter two parameters were controlled for by having the microphone in fixed suspension above the centre of the pen, reducing the need to have the chick facing in any one direction during testing. The rate of calling was also examined. Measurement of the seven parameters was possible by selecting the entire call, then holding down the command key and clicking the mouse button. This logged all measurements to Canary datalog window for further analysis. Seven chicks produced the three calls types, and three examples of each call type were analysed.

Statistical Procedures

The data for each of the three call types of each chick were averaged and analysed using a two way ANOVA, Scheffe's method, (Edwards, 1972), and t-tests. As it was not possible to capture the highest frequencies of the long peeps for any of the chicks due to software constraints, a nominal maximum frequency of 11.1 kHz was assigned as the maximum frequency for the long calls. A t-test was used to compare the short and medium peeps for the parameters of maximum frequency and difference between maximum and minimum frequencies. The loss of information on the long peep for energy and average power is minimal as the values for the peak frequency (see Table 1) indicates that the maximum values for energy and power to be well below the nominal maximum range of 11.1 kHz. Therefore, statistical comparisons were applied to these and the other parameters.

The cassette tapes of the seven chicks used in the statistical analysis were further examined to see if call types could be considered discrete or part of a continuum. The taped recordings were examined using SoundEdit Pro 1.0 on a Mac II vx. This enabled investigation of the tapes in 30 second sections. As the three call types were acoustically distinct it was possible to determine where calls changed from one call type to another. Waveforms and power spectrums were produced for the change over points and saved in SoundEdit format, a file format readable by Canary 1.1. This allowed the production of spectrograms of these call for a more detailed analysis.

RESULTS

A description of the peep call

The peep calls were identified first by an aural inspection of the tapes and then by a visual inspection of the spectrograms. This method is similar to that used by Seyfarth, Cheney and Marler (1980) with three different vervet monkey alarm calls. Classification of the calls was facilitated by their occurrence in bouts of calls with the same structure. Andrew defined a bout as "a group of calls, separated from each other by intervals of .20 sec. or less" (1963, p. 934).

The peep call is characterized by descending frequencies. Seven of the 12 chicks produced three distinct peep types that are classified

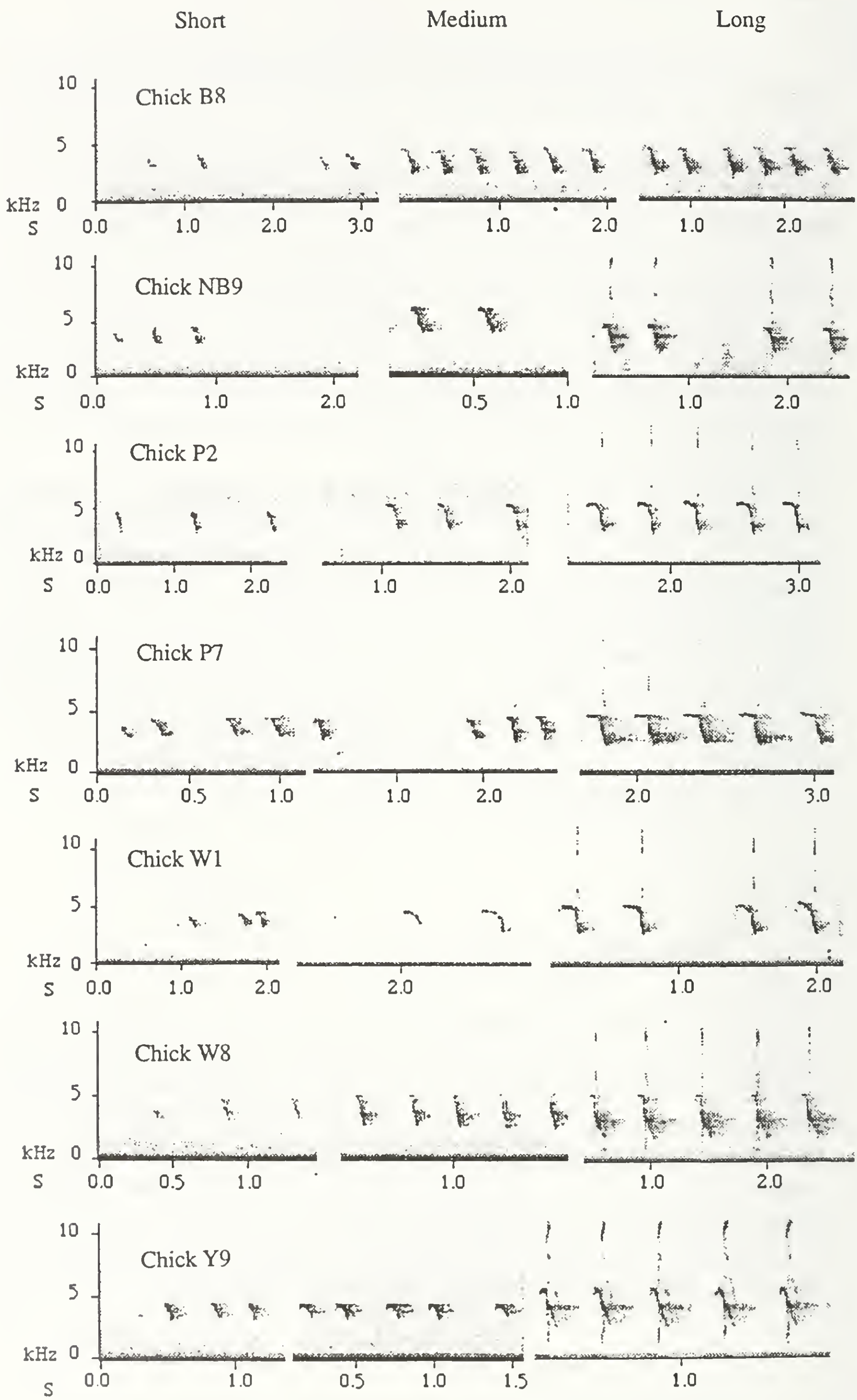
Short
Medium
Long
Chick B8
Chick NB9
Chick P2
Chick P7
Chick W1
Chick W8
Chick Y9
kHz
s

Figure 2. On the previous page are shown spectrograms of the short peep (left column), medium peep (middle column) and long peep (right column) emitted by the seven chicks on days 5-6 post-hatching. The identity of each chick is located in the upper left hand corner above the short call.

here as short, medium and long peeps and are the subject of statistical analysis. Of the remaining five chicks, three emitted medium and long peeps and two other chicks emitted long peeps only. The short peep was short in duration and had a relatively narrow frequency (kHz) range when compared to the medium calls. The short peep had a single descending frequency slope and has the least complex structure. The medium peep had a greater frequency range (kHz) and a short upper inversion indicating that the medium peep contains an ascending element that was not present in the short peep. The long peep had the most complex structure which occupied a wider frequency range than either the short or medium peeps. The upper inversion present in the medium peep is also present in the long peep and is more evident (Figure 2).

Parameter analysis

The long peep is, as its name implies is longer in duration than either the medium or short peep and it also has a greater maximum frequency, lower minimum frequency and has greater power and energy than either the medium or short peeps (Table 1). Further, for the parameters of duration and peak frequency, the coefficient of variation (c.v.) becomes lower as the peeps increase in length. This indicates that the long peep is a more stable form of peeping. However, for the peak frequency there is a remarkable similarity between the short, medium and long peeps (means = 3.5973 kHz, 3.2082 kHz, 3.4568 kHz respectively) and a low C.V. The minimum frequency on the other hand, has an increase in variation as the calls lengthen.

A two-way ANOVA showed a significant difference between calls (short, medium and long) for duration, minimum frequency, energy, average power. No significant differences between chicks were found except for average power (Table 2 (a)). A significant difference was found between short and medium peeps for the difference between maximum and minimum frequencies (see Table 2 (b)).

Table 1. Mean, Range, S.D., Coefficient of Variation (C.V.) of seven physical parameters for the three peep vocalizations (n=7 chicks). Three peeps for each call type for each chick were used. C.V. is not included for maximum frequency and difference between max. and min. frequencies, as true measures of these parameters are not available.

Parameters	Call Type	Mean	Range	S.D.	C.V.
Duration (ms)	Short Peep	146.9	61.8 - 213.5	53.9	36.7
	Med. Peep	240.7	183.8 - 314.4	49.5	20.6
	Long Peep	325.9	283.1 - 382.5	37.2	11.4
Maximum freq. (kHz)	Short Peep	4.3	3.2 - 3.7	0.4	8.1
	Med. Peep	4.9	4.5 - 6.1	0.3	11.6
	Long Peep	11.1	11.1 - 11.1		0.0
Minimum freq. (kHz)	Short Peep	2.9	2.6 - 3.2	0.2	6.3
	Med. Peep	2.5	2.2 - 3	0.7	9.9
	Long Peep	0.7	0 - 2.7	1.2	172.0
Difference between max. and min. frequencies (kHz)	Short Peep	1.4	0.8 - 1.9	0.3	23.6
	Med. Peep	2.4	1.7 - 3.6	0.6	28.4
	Long Peep	10.4	8.4 - 11.1		
Peak frequency (kHz)	Short Peep	3.6	3.2 - 4.4	0.4	12.3
	Med. Peep	3.2	2.7 - 4.1	0.5	16.1
	Long Peep	3.6	3.1 - 4	0.3	9.8
Energy (Watts)	Short Peep	8.0	1.9 - 20	6.6	82.7
	Med. Peep	20.7	9.3 - 51.4	14.1	67.9
	Long Peep	81.0	53.8 - 99.1	15.5	19.1
Average Power (Joules)	Short Peep	1.3	0.2 - 2.5	1.0	76.3
	Med. Peep	4.8	3 - 10	2.5	51.6
	Long Peep	27.2	16.2 - 37	7.1	26.2

Table 2(a). Two-way repeated ANOVA for five parameters on the three Peep vocalizations, short, medium and long (n=7 chicks).

Parameters	Chicks		Calls	
	F	P	F	P
Duration	1.2	NS	26.7	P<.005
Minimum frequency (kHz)	1.2	NS	20.1	P<.005
Peak frequency (kHz)	1.9	NS	1.8	NS
Energy (Watts)	1.3	NS	78.2	P<.005
Average Power (Joules)	3.05	P<.05	111.9	P<.005

Table 2(b). T-test for short versus medium mean peep vocalisations (n=7 chicks).

Parameters	Short Peep	Medium Peep	T	P
Maximum frequency (kHz)	4.3	4.9	0.5	NS
Difference between max. and min. freq. (kHz)	1.4	2.4	3.4	P<.01

The difference between the short, medium and long peeps for the parameters of duration, minimum frequency, energy and average power were examined using Scheffe's method (Edwards, 1972) (Table 3). A significant difference in duration (ms) was found between all three call types. For the parameters of minimum frequency, energy and average power a significant difference between short and long and between medium and long peeps were found.

Table 3. Multiple Comparisons using Scheffe's Method (Edwards, 1972)

Parameters	Comparison	F	P
Duration (ms)	Short v Med. Peeps	14.6	P<.01
	Short v Long Peeps	53.3	P<.005
	Med. v Long Peeps	12.0	P<.005
Minimum Frequency	Short v Med. Peeps	0.9	NS
	Short v Long Peeps	34.9	P<.005
	Med. v Long Peeps	24.7	P<.005
Energy	Short v Med. Peeps	2.4	NS
	Short v Long Peeps	132.7	P<.005
	Med. v Long Peeps	99.3	P<.005
Average Power	Short v Med. Peeps	5.9	NS
	Short v Long Peeps	196.0	P<.005
	Med. v Long Peeps	133.8	P<.005

Rate of peeping

The mean duration for successive calls between the beginning of one peep and the beginning of the next was established for each chick. Three short and three long peeps from each chick were used, and three medium peeps from five chicks and two medium peeps from the other two chicks were used. The mean rate of peeping for the short, medium and long peeps; = 1.99/sec., (SD = 0.9915); 1.13/sec., (SD = 0.911); 2.46/sec., (SD = 0.475) respectively. While the long peep is emitted at a faster rate than either the medium or the short peep, the difference in rate between call types was not significant, (F= 0.46, N.S. between calls; F= 0.81, N.S. between chicks).

The stability of acoustic parameters

The similarity between peeps was examined using the Pearsons Product-Moment Correlation (r). Two successive short, medium and long peeps from each of the seven chicks were selected and compared. As can be seen from Table 4 there is a significant positive correlation for the short, medium and long peeps for duration. Ten of the sixteen correlations on the other six parameters are significant.

Table 4. Pearsons product-moment correlation coefficient (r) of the first and second peep calls for each call type (short, medium and long) (n=7 chicks).

Parameters	Call Type	r	P
Duration (ms)	Short Peep	0.83	P<.025
	Med. Peep	0.92	P<.005
	Long Peep	0.91	P<.005
Maximum freq. (kHz)	Short Peep	0.65	NS
	Med. Peep	0.99	P<.001
	Long Peep	-	-
Minimum freq. (kHz)	Short Peep	0.89	P<.005
	Med. Peep	0.70	P<.05
	Long Peep	0.99	P<.001
Difference between max. and min. frequencies (kHz)	Short Peep	0.55	NS
	Med. Peep	0.90	P<.005
	Long Peep	-	-
Peak frequency (kHz)	Short Peep	0.73	P<.05
	Med. Peep	0.57	NS
	Long Peep	0.96	P<.001
Energy (Watts)	Short Peep	0.65	NS
	Med. Peep	0.75	P<.05
	Long Peep	0.64	NS
Average Power (Joules)	Short Peep	0.84	P<.01
	Med. Peep	0.90	P<.005
	Long Peep	0.45	NS

Are calls discrete or continuous?

Both Andrew (1963, 1964) and Collias (1987) argue that on occasion the peep (distress call) and twitter (pleasure call) of the chick grade into each other to produce new calls i.e. the chevron call and the circumflex call. We attempted to investigate whether this was true for the three types of peep call described above. Therefore, the three types of peep could exist as either a discrete call sequence or as a sequence that changes from one call type to another in a given bout. Three different chicks moved from short to medium to long peeps in a short time period (see Figure 3). Reber (1985) defined the term discrete as "separate, distinct, individually identifiable and discontinuous" (p. 205), while a

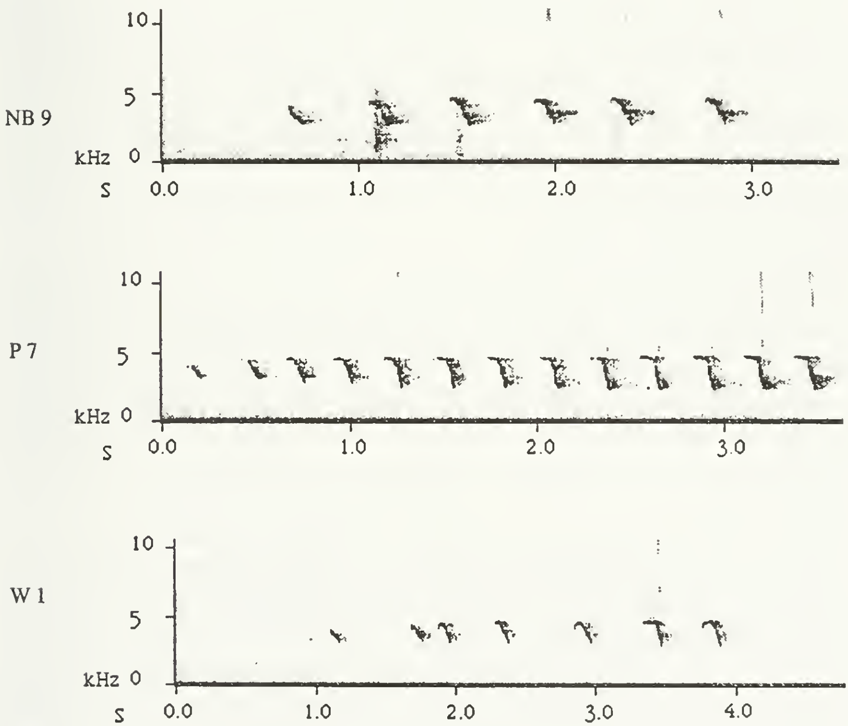

Figure 3. Spectrograms from three chicks of the three calls moving from short to medium to long (left to right). The identity of the chicks is located in the left hand margin. Only chick P7 produces the three call types in a single bout

continuum is defined as "any uninterrupted series of changes, any continuous gradually changing sequence of values" (p. 154).

The three peep types produced by one chick in a sequence of calling (see chick P7 Figure 3) are are the same as the calls that appear in individual bouts of calling (see Figure 2). Thus, these calls can change from short to medium to long in a single bout. The three peep types can be produced in discrete form and this is the most prevalent form of calling. In general it is also indicated that the chick pauses before changing from one type of peep call to another. However, it is evident that the three calls can also be produced in the same bout as illustrated in Figure 3 (chick P7).

DISCUSSION

The main finding of this study is the change in the structure of the peep vocalization during the 5 minute test period. The short peeps are similar to the short peep presented by Andrew (1964), the medium peep is similar to the distress call of Collias and Joos (1953) and the long peep is similar to the "Le cri d'appel du Poussin isolé" presented by Guyomarc'h (1962) (see Figure 2 and Wood-Gush, 1971, pp. 28-29). This study demonstrates that these three peep types can be produced by the same chick.

One of the underlying problems involved in the analysis was the distinction between discrete and continuous call types. All three call types have a similar basic structure in that they have descending frequencies. The three different calls show no significant differences in their peak frequency (see Table 2 (a)). The range measures for peak frequency show considerable overlap for the different call types (see Table 1) indicating that chicks tend to emphasise frequencies between 2.5-4.5 kHz for all call types. This shows that the different call types have a similar internal frequency-power structure. Second, these calls occur in the same context, i.e. there are no changes in the environment external to the animal during the recording session though the duration of the separation from cage mate increased over the 5 minute recording session. Other extraneous factors are unlikely to have influenced peep calling as the same heat lamps were used in the rearing and testing situation maintaining the temperature at a constant state. Thus, the calls have a similar basic physical structure and occur in the same experimental context.

Despite the similarity in basic structure, different forms of the call are evident, in visual inspection of spectrograms (see Figure 2) and in statistical analysis of call parameters. Variation in the use of energy and average power indicates that there is a greater investment of energy in the calls as they move from short to long (see Tables 1, 2 (a), 3). A significant difference in duration exists for all three call types (Table 3). Significant differences exist between the short and long peep and between the medium and long peep for the parameters of minimum frequency, energy and average power (Table 3) and between maximum and minimum frequency (Table 2 (b)). Further, successive calls show a high degree of similarity evident by the statistical significance of 13 of 19 correlations performed on the seven parameters of the three peep types (Table 4).

However, range Figures (Table 1) for five of the seven parameters indicate that short and medium peeps overlap each other. These results suggest that a continuum may exist between short and medium peeps. Further, the coefficient of variation (c.v.) (Table 1) is lower for the long peep on all parameters except for minimum frequency. The greater variation (c.v.) in the short and medium peeps suggest that these two calls could merge into each other or develop from short to medium in a bout of calling. Under the current definition of a bout we are restricted to evidence from only one chick (see Figure 3, chick P7). However, an auditory inspection of the tapes and a visual inspection of the spectrograms (Figure 2) indicate that the three call types are distinct although differences between the long peep and the other two are more pronounced. This is further supported by a significant difference between the call types for the parameters of energy and average power in the statistical analysis. Different peep types can occur in the same bout although the calls maintain their distinctive physical structure as evident in Figure 3.

The Peep in context

Kaufman and Hinde (1961) found that isolated chicks in a strange pen produce distress calls (peeps) at a higher rate if the environmental temperature is lower than body temperature. Andrew (1964) focused on the twitter and has shown that with increased intensity of stimulus contrast associated with the presentation of food there is an increase in intensity of the twitters as shown by increased length , pitch and number of trilling cycles. In Andrew's (1964) study the chicks were presented with food which may be regarded as a positive stimulus. In this study the chicks were separated from a companion and such separation is associated with an increase in peep vocalizations (Collias, 1952; Kaufman and Hinde, 1961; Evans, 1975).

Bermant (1963) found that the rate and intensity of distress calling (peeping) increased with an increase in the degree of maternal isolation. Chicks that were alone emitted more distress call than chicks that could see and not hear the mother hen, who in turn emitted more peeps than chicks that could see and hear the mother hen. According to Collias (1987) and Collias and Joos (1953) distress calls (peeps) and pleasure notes (twitters) reflect the basic security-insecurity balance that governs chick behaviour. In the study of Bermant (1963) the chicks experienced graded levels of insecurity. Evidence from imprinting studies show that there is an increase in distress calling when a familiar imprinting object is removed (in chicks, Brown, 1979; in ducklings, Hoffman, 1968; Hoffman *et al.* 1974). The chicks' peeps affect the behaviour of the mother hen. Hughes *et al.* (1982) found that the sound of the chicks' peep vocalizations elicited approximately four times more food calling from mother hen than the sight of a silent chick. Evans (1975) points out the vocal interaction between hen and chick serves to maintain family unity.

The main finding of this study is that the same chick can produce three different types of peep call. These can be emitted in discrete bouts (see Figure 2) or in the same bout (see chick P7, Figure 3). The peep call is emitted in several situations. It occurs when a companion is removed (Bermant, 1963), when environmental conditions are not optimal (Kaufman and Hinde, 1961) and following the removal of a imprinting object (Brown, 1979). It also produces a specific reaction from the broody hen (Evans, 1978; Hughes *et al.*, 1982). The purpose of this paper was to examine in detail the three peep types of the chick. This was achieved by giving a detailed analysis of the three different peep types. Although the chick gives three types of peep call it is a matter for further investigation to determine if the different peeps perform separate functions and to determine what these functions are.

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