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Communication of Young Black-Tailed Gulls, *Larus crassirostris*, in response to Parent's Behavior

Hoon Chung*, Seokwan Cheong and Shi-Ryong Park

Department of Biology Education, Korea National University of Education, Cheongwon 363-791, Korea

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In the breeding colony of black-tailed gull, as nests of conspecific neighbors are very closely located, chicks are permanently exposed by sound and visual stimuli produced by adult conspecifics approaching their nests. The chicks, therefore, may need to learn ways to appropriately respond to their parents approach. In this study we experimentally manipulated sensory stimulation that is potentially provided by the parents to the offspring. Chicks incubated in the laboratory were exposed to a mew call of the conspecific adult. Then they were tested in three situations differing in sensory stimulation: 1) visual stimulation only, 2) auditory stimulation only, and 3) Simultaneous visual and auditory stimulations. We observed occurrence of different response of the chicks, which were categorized into three behaviors (begging call response, chirirah call and pecking behavior). We also investigated intensity of the chick's call in response to the different stimulations and the degree of response with age. The chicks exposed to only auditory stimulation made significantly more chirirah calls. The intensities (dB) of the mew call and chicks' chirirah call were directly correlated. On the other hand, when chicks just saw the stuffed adult gull, they responded significantly more with a begging call and pecking behavior. In the situation of costimulation, the chicks responded with a begging call and pecking, but less frequently than visual stimulation only. The results suggest that young black-tailed gulls use call repertories to properly respond to parents behavior. Such results suggest an evolutionary process for uncreasing their survival rate in a group breeding site.

Group-breeding birds rely particularly on auditory, rather than visual, sense for kin recognition (Stevenson et al., 1970). Harper (1986) reported in terms of predictable theory of natural selection that in the case that parental birds invest for their young instead of their parents, it is because they face something disadvantageous, and their relative-recognition is evolutionarily developed.

Studies on vocal communication have been more actively conducted in Laridae Vocal signals have been adapted in various ways through evolutionary process in a group-breeding site (Stevenson et al., 1970). Gulls have a particularly large and complex vocal repertoire, and some calls have been categorized according to functions and circumstances (Beer, 1969, 1976; Stout et al., 1969). Such a complex vocal signaling is important for parent-offspring in a group-breeding site (Tinbergen, 1953; Evans, 1970; Beer, 1970; Burger, 1974). Gulls generally recognize individuals by applying their visual or auditory senses, or sometimes both (Burger et al., 1988). After hatching, young gulls are frequently exposed to both auditory and visual signals from their parents. Two mechanisms for development of individual recognition are suggested. (1) The simultaneous presence of visual and auditory stimuli from the parent causes pairing of the parental call with visual imprinting, leading to selective reinforcement of the familiar call and hence to individual call recognition. Evidence in support of this hypothesis was recently obtained for young ring-billed gull (Evans, 1977). (2) Since parents commonly emit calls while feeding the chick (Tinbergen, 1953; Evans, 1970), feeding in the presence of a parental call allous young gulls to learn to recognize and respond selectively to individually distinctive parental calls. An experimental test of this hypothesis for laboratory-reared young ring-billed gulls is the primary objective of the present study.

Young black-tailed gulls that are 3-5 days after the hatching respond to their parents more significantly than to non-parents (Rho and Park, 1993). A recent study suggested that young black-tailed gulls promptly recognize simple characters of parental gulls' various call

*To whom correspondence should be addressed.
Tel: 82-43-230-3719, Fax: 82-43-233-6263
E-mail: gull@korea.com

signals in 2-3 days after hatching (Park and Chung, 2002). Behavioral changes of young gulls according to parental call have been studied by some of ethologists in the past (Beer, 1970; Evans, 1986). Laboratory studies have shown that various adult calls can produce different effects on approach and vocal behavior of the chicks (Beer, 1970; Impekoven, 1976; Evans, 1980). However, fewer studies have examined chicks' responses to behavioral changes of parents.

At the mass breeding places of black-tailed gulls in Korea, the distance between nests is approximately 1.1 m and on average, there are 13 nests for 10 m^2 (Kwon, 1999), a very high density. The black-tailed gull is a locally abundant species with semi-precocial chicks that are fully dependent on parental care for food prior to fledging (Kwon, 2004). The optimal respond of chicks to parents prevents attack of adult gulls, and therefore increases survival rate in breeding sites.

Young black-tailed gulls respond to parents with three types of behavioral signals: begging call, pecking, and chirirah calls (Chung, 2000). Begging and pecking are honest signals communicating a chick's nutritional need to its parents (Ryden and Bengtsson, 1980; Hussell, 1988). The chirirah call is young gulls' answer to mew calls and its function has not been elucidated. It is assumed that the signals are used to let their locations be known or for recognition between siblings or parent-young gulls (Park and Park, 1997; Chung, 2000).

This study observed the chicks' behavior (begging call response, chirirah call and pecking behavior) in response to artificial parents' stimulations: 1) visual stimulation only, 2) auditory stimulation only, and 3) visual and auditory stimulation.

Materials and Methods

Eggs collection

On May 18, 1998. 25 eggs were collected in Nando (36°40′20″E, 126°03′50″N), located at Gauido-ri, Geunheung-myeon, Seosan-gun, Chungcheongnam-do, which is known as a group breeding site for black-tailed gulls. When they were collected, 2 or 3 eggs were selected in each of the 9 nest and the eggs of each nest were identified with an oil pen. This allows the same brood to stay together.

Artificial incubation

The eggs were artificially hatched in the laboratory. The temperature of the incubator (Lyon, Model RX2) was maintained at 37.5±0.5°C, with the relative humidity 70±5%. Of the 25 eggs collected, 20 hatched. Colored plastic rings were fixed to their legs to distinguish each hatched individual. They were kept in paper containers (55×55×60 cm), 2 or 3 blood lines in the natural state in each container (7 clutches) for keeping in a remote place. The temperature of the breeding boxes was kept at 37±0.5°C with a radiator plate, and 2 weeks after their hatching, they were kept at room temperature. Paper containers were put in each box, and replaced everyday.

Learning

All chicks were fed with yellow corvina every 2 h from 09:00 to 21:00 with a stuffed conspecific adult. Adult black- tailed gull sounds (mew call) were played back for 1 min 30 sec before the feeding.

Adult calls from Hong-do, Mujuk-ri, Hansan-myeon, Tongyeong-gun and Gyeongsangnam-do (34°31′E, 87″, 128°43′88″S) were recorded using an Uher 4000 Report IC tape recorder. Among them, the 7 best individual recordings were selected to tutor the chicks. To imitate natural variance in call, different adult calls were used for each clutch set.

Experimental manipulation

1. Auditory stimulation only

After giving three auditory stimulations (70 dB, 85 dB, 100 dB) to chicks, their response was observed for 2 min, which is the response case of hearing parents' mew call without seeing the parents' model. For the sound playback, Sony cassette recorder TCM-929 was used with a speaker installed 50 cm from the keeping places. For call intensity (dB) estimation of the playback tape, a sound level meter (Larson and Davis model 800 B) was placed 50 cm from the speaker (JBL pro III).

Behaviors of the chicks were recorded and divided into begging call, chirirah call and pecking behavior. We also measured call intensity of chicks according to adult mew call intensity. A sound level meter (Larson and Davis model 800B) was placed 20±5 cm from the chicks.

For stability of the experimental objects, food was supplied 1 h before the start of the experiment. Individual subjects were moved to experiment boxes (55×55×60 cm) and were allowed to calm down for 3 min. This experiment was conducted among 5 age classes (1-2, 4-5, 7-8, 14-15 and 21-22 days after hatching), used by Evans (1998) in his ring-billed gull experiment.

2. Visual stimulation only

We recorded the chicks' response for 2 min, which is seeing parents' model without hearing parental call. We used stuffed conspecific adult for visual stimulation. This experiment was also conducted 5 age classes.

3. Visual stimulation and auditory stimulation simultaneously

After giving parents' visual and auditory stimulation to chicks, their response was observed for 2 min. Which is the response case of giving parental mew call, while seeing parents' model (stuffed conspecific adult). This experiment was also conducted 5 age classes.

Statistical analysis

We used SPSS (version 11.0) for statistical analysis. The Mann Whitney U test was used to test difference of the chick's responses in different experimental situation. One-way ANOVA test was used to analyze chick's response to call intensity. We used repeated measures analyses of variance (ANOVA) with alpha of 0.05. We used linear mixed models for analyses between age classes and response (chirirah call, begging call, and call intensity).

Results

Auditory stimulation only

The call intensity of chirirah call response was the highest in the 100 dB mew call than 85 dB or 70 dB (n=20, F=248.656, P<0.001; Fig. 1). In contrast, chirirah call intensity response was the lowest to the 70 dB mew calls. The chirirah call intensity tended to increase with age (y=1.5516x+84.013, R2=0.8325, P<0.001). When chicks heard parental mew call without seeing parental gulls, they responded mostly with chirirah call. Chirirah call rate was also significantly higher auditory stimulation (mew call) than visual stimulation only (z= -12.916, P<0.001) or visual and auditory stimulation (z= -9.355, P<0.001, Fig. 2). Chirirah call rate increased significantly with age (y=8.97x+33.71, R2=0.1625), but begging call rate and pecking rate were not significant.

Visual stimulation only

On the other hand, when chicks just saw parental gulls without hearing them, they responded with a begging call and pecking. The begging call rate was significant, with visual stimulation causing higher rate than auditory stimulation only (z=-10.628, P<0.001) or visual and auditory stimulations (z=-2.983, P<0.05, Fig. 3). The Pecking rate was also significant, with visual stimulation causing a higher rate than auditory stimulation (z=-11.925, P<0.001) or visual and auditory stimulations (z=-1.957, P<0.05, Fig. 4). Begging call rate (y=10.83x+47.04, R2=0.6033, P<0.001. Fig. 3) and pecking rate increased with age (y=9.763x+37.21, R2=0.8021, P<0.001, Fig. 4). Chicks 1-2 day old called significantly less than older chicks, and chicks at 4-5 days called less than those at 14-15 or 21-22 days.

Visual stimulation and auditory stimulation simultaneously

In the case of giving visual and auditory stimulation at the same time, chicks responded with begging call and pecking, less frequently than visual stimulation only. But begging call rate did not differ significantly in animals 14-15 and 21-22 days after hatching (Fig. 3) and pecking rate did not reach significance in 1-2 days after hatching (Fig. 4). Chirirah call rate responded less to auditory stimulation of parents.

Discussion

The black-tailed gull has eleven different vocal signals according to behavioral function (Park and Park, 1997) but chicks have two types of vocal signals; begging and chirirah calls (Chung, 2000). Chirirah call in the young black-tailed gull was mostly heard while playing back adult mew call without visual stimulation. A previous study shows young black-tailed gulls learn simple characters (call interval and call intensity) of parental mew call (Park and Chung, 2002). Accordingly, it seems that chicks learn parental mew call first and make chirirah call, to maintain social relationships with parental gulls. The alternation in call intensity (dB) shows that young black-tailed gulls' chirirah call is closely related to parental mew call.

According to this study, parental gulls' mew call and chicks' chirirah intensity are directly related. That is, the intensity of parental mew call influences the chicks' chirirah call. Generally, call intensity is closely related to the distance. Therefore, the chicks understand that their parents are far away when parental gulls' mew call was played back at low call intensity and vise versa. In this experiment, chicks showed high intensity chirirah call when the intensity of parental mew call was high. This is contrary to general theory. If chicks' chirirah call is a means of communication to inform their presence to their parents, chicks should respond to parents' lower call intensity with higher call intensity. It can be explained in terms of cost and profit. It is not beneficial and meaningful for chicks to raise the intensity of chirirah call and inform their parents who are unable to distinguish it. Therefore, according to Chung (2000), the frequency of chirirah call was decreased after a low intensity mew call. When chicks heard parent's with high intensity mew call, this means that the parents are close to the nest. They let their parents recognize them with their chirirah call and approach parents. Most parents breed chicks who make chirirah call and approach them even if they are not their own chicks and attack chicks who do not make chirirah call and chase them away, bending down (Beer, 1976). It is considered that parents adopt chicks that recognize them but attack chicks that reject them.

In this study, chicks aurally stimulated by parents

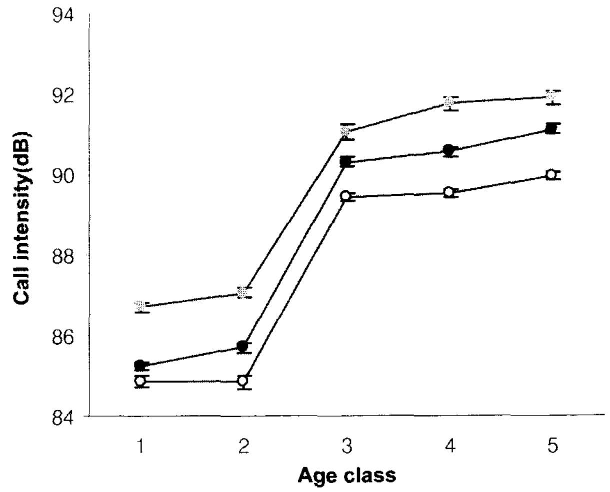

Fig. 1. Chicks' chrirah call dB (calls/2 min) for 70 dB (-○-), 85 dB (-●-) and 100 dB (-◉-) mew call over five age classes are (1) 1-2 days, (2) 4-5 days, (3) 7-8 days (4) 14-15 days and (5) 21-22 days. Mean±SE (n=20).

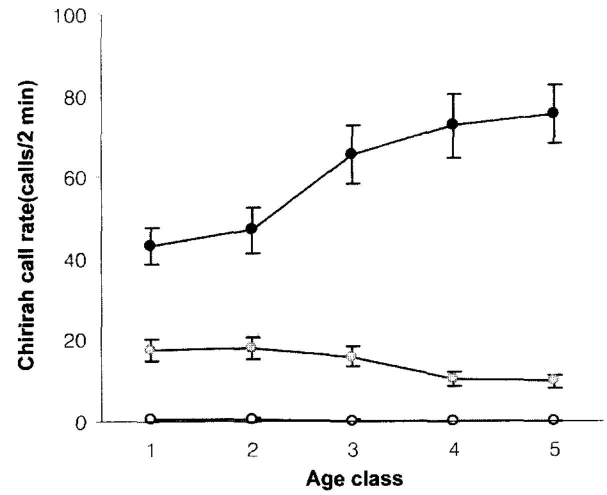

Fig. 2. Chicks' chirirah call rate (calls/2 min) for visual(-○-), auditory(-●-) and visual and auditory(-◉-) parents stimulation. The five age classes are (1) 1-2 days, (2) 4-5 days, (3) 7-8 days (4) 14-15 days and (5) 21-22 days. Mean±SE (n=20).

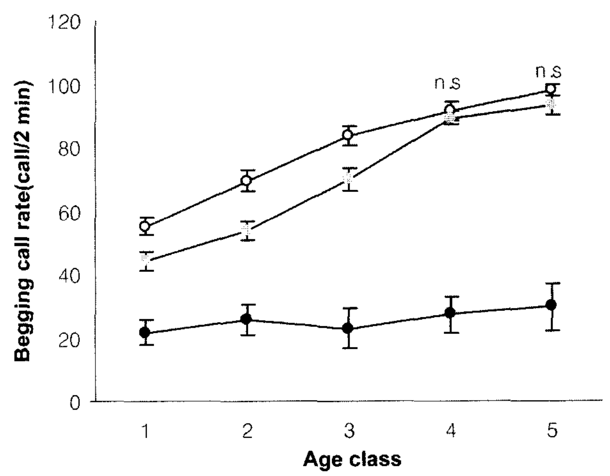

Fig. 3. Chicks' begging call rate (calls/2 min) for visual(-○-), auditory(-●-) and visual and auditory(-◉-) parents stimulation. The five age classes are (1) 1-2 days, (2) 4-5 days, (3) 7-8 days (4) 14-15 days and (5) 21-22 days. Mean±SE (n=20).

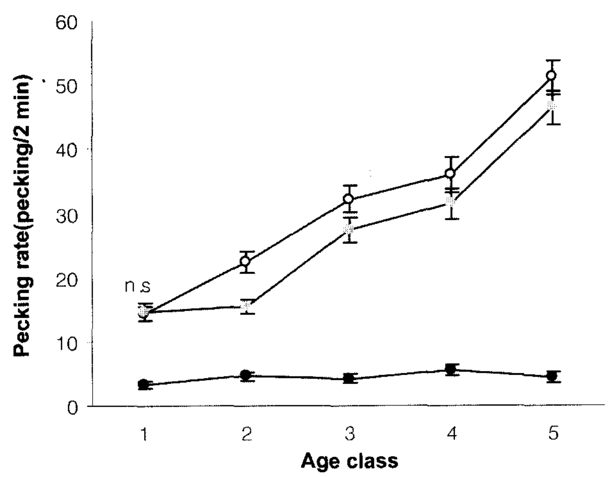

Fig. 4. Chicks' pecking rate (calls/2 min) for visual(-○-), auditory (-●-) and visual and auditory(-◉-) parents stimulation. The five age classes are (1) 1-2 days, (2) 4-5 days, (3) 7-8 days (4) 14-15 days and (5) 21-22 days. Mean±SE (n=20).

responded with a chirirah call, while most of those visually stimulated responded with a begging call. Chicks visually stimulated approached the parents' model and continuously made a begging call and pecking. Such a begging behavior shows high relations with parents' visual stimulation. It is considered to be due to the evolutionary character of begging. Begging vocalizations are honest signals communicating a chicks' nutritional need to its parents (Bengtsson and Ryden, 1983; Hussell, 1988). Generally, begging is closely related to chicks body condition. For example, food deprivation results in increased begging and increased provisioning, whereas satiation results in reduced begging and reduced provisioning (Redondo and Castro, 1993; Whittingham and Robertson, 1993). It is known that evolutionarily, chicks level of begging is quantitatively formed by optimal trade-offs with parents' distribution of feeds (Whittingham, 1989; Yasukawa et al., 1990; Patterson, 1991; Whittingham and Robertson, 1993; Burford et al,, 1998; Chung, 2004). If it is assumed that the recognition between parents-offspring is mostly made by chicks, it would be meaningless for chicks to generate begging call when their parents are not seen. Dearborn (1998) explained about chicks' begging in terms of energy costs and Haskell (1994) pointed out the predation risk of begging. Likewise, it will bring about disadvantage to their survival rate in terms of energy and predation risk that young black-tailed gulls communicate with parents who are unable to recognize their calls with a begging call. It is considered that chicks became evolved not to make begging call where their parents are not seen, for this reason. It seems that chicks stimulate parents with begging after having confirmed their existence with chirirah call. In order to supplement such a hypothesis in this study, we showed parent model to chicks and then playedback parental mew call to chicks. At this time, the chicks' response was intermediate between the cases of visual stimulation and auditory one. Namely, the chicks both visually and auditory stimulated at the same time made a chirirah call and a begging call. They made an immediate response to parental mew call with chirirah call and approached the parent model, for begging call and pecking or to continue chirirah call. Chirirah call made near the parent model may be because there was no recognition relationship with parents. A mew call in natural condition is used when parents recognize their chicks, but after the formation of recognition relationship with the chicks, parents no longer make mew call and the chicks also do not make chirirah call (Chung, 2000). However, it seems that chicks show a bit of chirirah call, since the parental mew call continued in spite of their approach to the model just like in our experiment. At this time, the intensity of chirirah call was higher than that aften aural stimulation only, but this cannot be proven statistically. Such a tendency can be seen as a means of giving more confirmation on recognition relationships with the continuous mew call. Even though we could not statistically prove this detailed research using other methodology would be needed.

In conclusion, young black-tailed gulls seem to have evolved to minimize energy and decrease predation risk in order to play a decisive role in recognition relationships with parents and raise survival rates during the process. If parents recognize their chicks, the results would be a different. It is not clear if it is because they are unable to form search images for various changes according to the growth, or if it is beneficial to selfish individuals or to group advantage that parents can not recognize their chicks. However, just like this study, it seems that chicks' selective behavior of chirirah call and begging call positively influence the survival of chicks in a group breeding place. Chicks' behavior to raise survival rate in the nest with high reproduction is considered to be the result of natural selection in the group. Such behaviors must have been made through a delicate process of reproduction between parents and chicks. Our study does not sufficiently cover everything. We expect to solve every question through future studies on social behaviors between parents' black-tailed gulls and chicks.

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