Visual signalling in Canada Geese for the coordination of family units

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Introduction

Canada Geese *Branta canadensis* use a variety of head movements that are enhanced by their white-on-black cheek patch. Visual signals are defined as a movement emphasised by a feature which has evolved to serve in visual communication, usually by releasing certain patterns in conspecific individuals (Fabricius 1975). Most head movements in Canada Geese that have been previously identified and described (see Fabricius 1977; Akesson & Raveling 1982 for reviews) have multiple functions, but are specialised in communicating threat to neighbours. Visual signals or display in Canada Geese during agonistic and triumph ceremony situations are thought to be adaptive in that they aid the reinforcement of pairbonds and possibly enhance both the establishment of nesting territories and breeding success (Akesson & Raveling 1982; Black & Owen, in press).

This study concentrates on visual signals by family members during the post-hatch season. Analysis was limited to two head movements: *head-tossing* – a lateral, vertical, or rotary movement of the head usually while the neck is held vertically straight, and *head-pumping* – a lowering of the head toward the breast and raising it again to a vertical position or at various angles to the body.

Other authors have reported a close connection between head-tossing and aggression. Head-tossing demonstrates conflicting tendencies to either stay in one place to protect goslings possibly by attacking neighbours, or to flee from an aggressor (Collias & Jahn 1959; Radesater 1974). The signal has also been described as occurring when an individual is about to move to a new location by walking or flying (Raveling 1969; Radesater 1974). Head-pumping indicates a balance in the tendencies to attack and escape (Blurton-Jones 1960; Raveling 1970) which may, therefore, lead to locomotion. To test the locomotory element of visual signals we recorded the type and number of head movements and timed the interval between the last signal and the initiation of walking or swimming.

Methods

The first few geese from which the study flock originated (now about 150 birds) came from Seney National Wildlife Refuge, Michigan, in 1957. Head and neck movements were filmed with a Super 8 camera or noted opportunistically between May and July in 1980. Corn was supplied for the free-flying geese each morning (1000 hours) at a 1.2 hectare pond.

The number and type of head movements (signalling bout) were counted until the behaviour changed, to grazing, preening, walking or swimming, etc. When signals were performed by birds that were stationary (standing on land or sitting on water) we recorded the elapsed time until any subsequent locomotion. The number of head movements was also counted during signalling bouts when the bird was already moving. The signals included in this report are distinguishable from preflight intention because of the noticeable absence of the low gutteral sound that accompanies preflight signalling (Raveling 1969).

In the 1979 breeding season six feather-cut pairs that hatched and reared goslings were kept in individual pens (5m x 15m) where they were easily watched during the first three weeks after hatching. After the female parent initiated a signalling bout the following response of the goslings was noted. Head and neck movements in the goslings were also counted. When a gosling performed a signal bout any locomotory response was recorded for the focal bird and its family members. The age at which signalling appeared in three small groups of human raised goslings was also recorded.

Results

Table 1 shows the number of head movements per signalling bout and the elapsed time before any responding locomotion. It also lists the number of head-tosses that were given when the bird was already moving. Head-tossing (Fig. 1) from a stationary bird resulted in locomotion for 88% of the bouts. Film analysis showed that

Table 1. Signals performed in different situations and the immediacy locomotion.

Signals type (Direction or situation)	Movements given per signal bout (stationary)	Time until locomotion by signaller Number and percentage			Movements given per signal bout (in motion)
	mean (range)	<2sec	>2sec	none	mean (range)
Head-toss (forward)	3.0 (1–10) N=123	106 88%	4 3% N=120	10 8%	7.4 (1–82) N=60
Head-toss (to the side)	1.3 (1–4) N=32	28 88%	0 0 N=32	4 13%	7.3 (1–9) N=13
Head-toss (obstructed)	14.8 (1–38) N=28	3 19%	8 50% N=16	5 31%	28.3 (20–34) N=5
Head-pump (warning or threat)	10.1 (1–27) N=51	0 0	0 0 N=42	42 100%	0
Head-thrust (forward)	3.2 (1–9) N=55	50 94%	1 2% N=53	2 4%	6.8 (1–22) N=20
Head-thrust (to the side)	2.3 (1–4) N=22	22 100%	0 0 N=22	0 0	2.4 (1–5) N=13

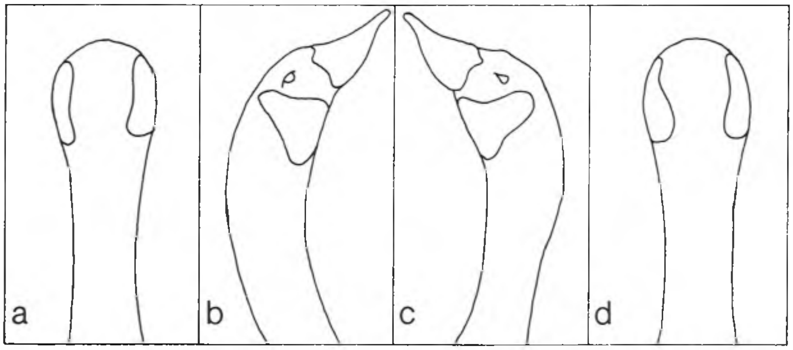

Figure 1. Frame by frame analysis of a typical head-toss given prior to the start of locomotion or when a bird is already walking or swimming.

at the end of a head-toss bout the goose sometimes initiated or changed the direction of its locomotion in the direction in which its bill pointed. When an individual was in front of an obstacle, such as a fence, the locomotory response was greatly delayed and the number of signals given from a stationary position increased nearly five-fold. Head-tossing continued for longer periods of time when the family began to walk or swim. In one case a male gave 82 head-tosses as he and his family swam the length of the pond.

Casual observation indicated that head-pumping by parent birds was mainly induced when another family was approaching from a distance, but the signal was also frequently displayed by wild families, in north-eastern Ohio, that were completely alone on their brood rearing ponds. Almost two-thirds (73 of 117) of the head-pumping bouts observed resulted in the initiation or continuation of locomotion. Head-pumps where the head returned to a vertical "alert" position did not result in locomotion. Close examination of the films indicated that when locomotion occurred the neck was extended out in front of the body at various angles from the last pumping movement (Fig. 2). Therefore, in Table 1, we called head-pumping, which resulted in locomotion, "Head-thrusts." Only twice (n=53) when a head-thrust motion was observed did the goose fail to proceed forward. As with head-tossing when the head-thrust pointed to the left or right the bird initiated or changed its direction of travel accordingly (Fig. 3). Head-pumping also occurred when the birds were mobile. Combined head-toss and neck-thrust bouts were also observed (n=27) in which the number of signals before motion was 6.5 (range 1–20) and 94% of the bouts resulted in locomotion.

In many situations vocalisations accompanied these signals. The type and intensity of the calls was determined by the proximity of family members. These calls have been adequately described by several authors (Collias & Jahn 1959; Radesater 1974; Akesson & Raveling 1982).

Head-tossing performed by females caring for young goslings was usually performed at the goslings' height. Head-thrusts were also performed close to the ground. There was little variation in the number of movements or in response time between these lowered signals and those performed with the head held vertically (Table 2). The only major difference in these lowered head movements was the observation that males rarely performed them, as they spent more time being vigilant while the female more actively directed the path of the goslings during the first days after the hatch. Another head-toss, performed by the female at ground level, was termed "grouping signal" because, together with a rapid succession of clucks, it functioned to bring the goslings together near the female's head. This head movement was much faster and more vigorous. The call which accompanied this signal may be similar in function to the grouping (mooing) call reported by Frazer & Kirkpatrick (1979) in Emperor Geese *Anser canagicus*. As goslings became older the frequency of response to this signal and call decreased. During the first four days three grouping signals were recorded where the goslings ran to the female within two seconds. Between the third and fifth day nine responses to the signal took more than two seconds and up to six seconds. The last observation of this female behaviour was on the ninth day, and the goslings did not respond at all.

Head-tossing by goslings began on the hatching day and steadily increased from day four until peaking at about 10 days (Fig. 4). These signals were readily distinguished from head shaking due to excess fluid in the nares. Only 12 head-pumps were given by

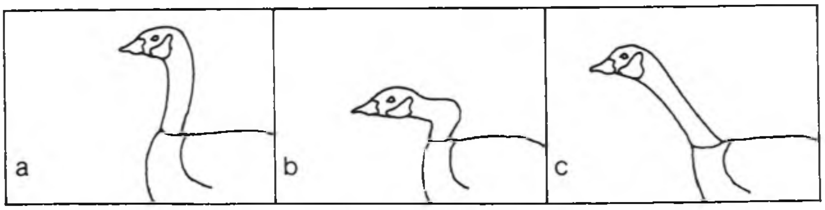

Figure 2. **A head-thrust, which is given prior to or during locomotion.**

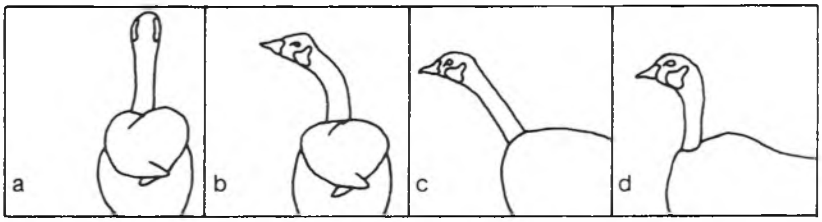

Figure 3. **A redirection head-thrust in which the movement in frame (b) indicates the direction in which the body and subsequent locomotion will follow (c & d).**

Table 2. Signals given by the female parent and goslings during the first three weeks after hatching.

Signals type (Direction or situation)	Movements given per signal bout (stationary)	Time until locomotion by signaller Number and percentage			Movements given per signal bout (in motion)
	mean (range)	<2sec	>2sec	none	mean (range)
Head-toss (lowered)	3.7 (3–14) N=12	12 100%	0 0 N=12	0 0	10.6 (1–19) N=16
Head-thrust	2.2 (1–8) N=10	10 100%	0 0 N=10	0 0	10.6 (1–20) N=18
Grouping signal	15.4 (5–42) N=13	–a	–	–	0
Head-toss (by goslings)	1.7b (1–17) N=67	47 80%	6 10% N=59	6 10%	– – –

a. See text.

b. Includes nine goslings all of which gave signals: three broods of two and three broods of one.

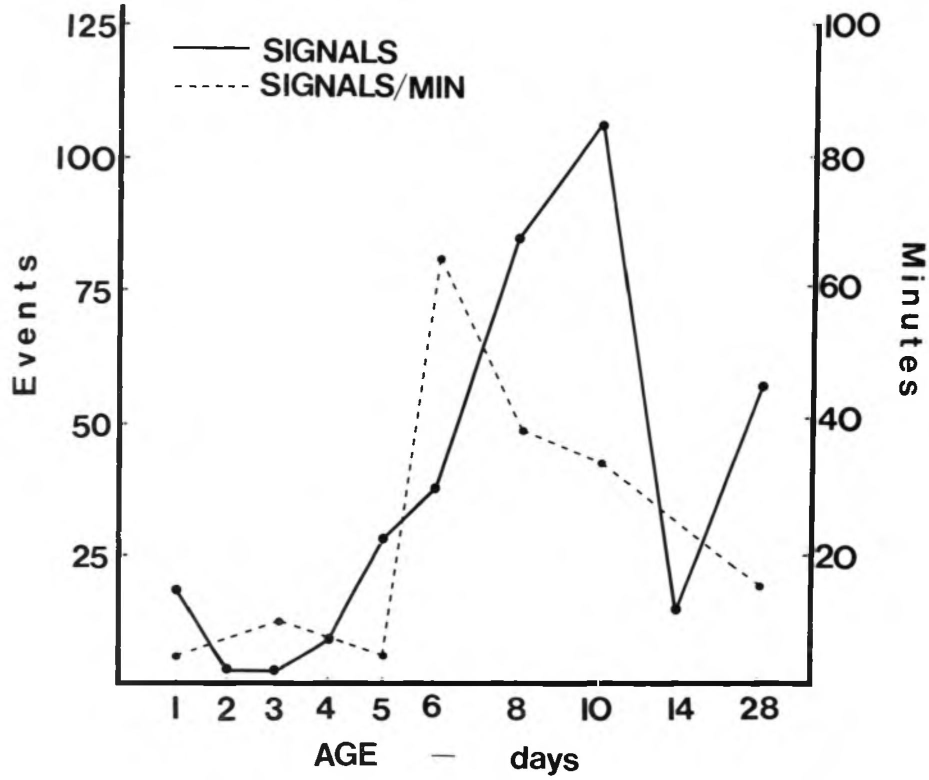

Figure 4. The development of head-tossing signals in parent-reared goslings which were followed by locomotory responses in the first 28 days after hatching. The *event* axis is for the total number of signals that were observed in 67 bouts. The *minute* axis is for signals that were recorded during filmed sequences.

two of the goslings, when they were three days old. They were looking directly at the gander which was also head-pumping about one metre away, so it appeared that they were mimicking his behaviour.

After 18 of 21 (86%) signal bouts, where the family members' responses were recorded, at least one member followed the goslings which had performed a head-toss bout, before running ahead to forage. In 12 (57%) cases both parents and siblings followed, and in three other situations none of the family members followed the gosling's movement.

There was little difference between goslings and adults in the number of signal bouts that resulted in locomotion whithin two seconds (Table 2). However, the number of head tosses given from a stationary position before locomotion began was larger for adults (mean 3.0) than for goslings (mean 1.7).

For the length of the study the human-raised goslings which had never seen head and neck signals did not perform them prior to or during locomotion. However, after two months three of these goslings were introduced to geese which gave signals and on the following day they performed head-tosses. Another group of three human-reared goslings were allowed to remain with their parents for part of the first day after hatching during which they left the nest. The parents performed many signals during this time. Beginning in the first two weeks these goslings gave many head-tosses. They especially performed them when they tried to follow their foster parent after being separated by the fence of the rearing pen. The incubator hatched goslings which had never experienced adult geese, on the other hand, did not give any signals in this situation.

Discussion

Due to the high percentage of bouts (from a stationary position) that were actually followed by locomotion of the signaller, it is evident that the head and neck movements described in this study are pre-locomotory signals. This is supported by the finding that the number of head-tosses drastically increased when a bird's forward progress is hindered and the motivation toward locomotion is assumed to be heightened. Because a stationary bird usually gives more than one head or neck movement before walking or swimming away there is more time to attract the attention of family members.

Head-pumping by parent geese appears to transmit a warning to approaching conspecifics, thereby advertising the position of their family. Besides threat functions, the conspicuous movement, as with head-tossing, serves to get the attention of family members so that a change in location or direction of travel can be synchronised among them. Once the family is mobilised, signalling not only continues to communicate a warning to neighbours but facilitates family cohesion and redirection of travel paths, thus alleviating conflict with other families. To stress the locomotory element of visual signals it should be mentioned that both signal types were observed in wild geese even when there were no conspecifics present which may have otherwise elicited such behaviour.

The white-on-black cheek patch made conspicuous by these head movements may be the initial directing stimulus, together with auditory cues (Cowan 1973), that newly hatched goslings respond to when the brood leaves the nest for the first time. This suggestion is supported by the effectiveness of the grouping signal, and other head movements that are performed close to the ground in front of young goslings. Indeed, the contrasting cheek patch is the first stimulus a hatchling perceives as the female slightly lifts her body and frequently bends her neck to "tuck-in" around the nest as the eggs hatch.

In the wild during the post-hatch period flightless geese often travel long distances on foot to brood rearing areas when gosling mortality is known to be high (Giroux 1980; Zicus 1981). A system of social signalling that functions to synchronise such efforts and that facilitates a cohesive family unit is presumably advantageous. Visual signals, instead of loud calling, would also allow families to escape undetected by predators during the flightless period. Such occurrences were observed when approaching wild birds; both the males and females silently gave head movements to direct their brood into cover. During other seasons flight is known to demand a great amount of energy reserves. It is also known that Canada Geese spend most of their time on the ground or in the water. For such a lifestyle, selective pressures would favour a communication system that would specialise in terrestrial or aquatic locomotion, since it would often be more cost efficient than flying, e.g. over short distances.

We found that goslings reared by their parents gave head and neck signals at an early age, and that human-raised goslings did not unless they experienced signalling by their parents during the first day. Human-reared goslings quickly developed head-tossing at two months of age after a brief exposure to the signal.

In the light of these findings it may be instructive to use these, or similar criteria as used in this study, to test if visual signalling behaviour in birds, which were reared apart from their parents, varies significantly from parent-reared (or wild) birds. It is our impression that the number of signals per bout, the presence or absence of locomotion and the time until locomotion (in the focal animal as well as its family members) will vary if the birds do not experience the behaviour early in life. In view of the possible functional adaptations associated with the signals in question, to the extent to which those functions are measurable, studies such as these may be as highly relevant to biologists who conduct reintroduction programmes on endangered species as it would be to aviculturists.

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Summary

In 88% of 120 observations when a stationary Canada Goose *Branta canadensis* was head-tossing the bird began to walk or swim within two seconds. The number of head-tosses increased considerably when the signaller stood in front of an obstruction. After 94% of the head-pumping bouts (n=55), when the signaller's neck was thrust away from the body, the bird began to walk or swim within two seconds. When the signal movement ended with the head and/or neck pointed to one side the signaller proceeded or changed course in that direction. Head and neck signals were also used when families were already walking or swimming, which seemed to reinforce, maintain, or redirect the initial movement.

Female parents performed the same head and neck movements at ground level near their young. During the first week after hatching goslings responded to a "grouping signal" by running to the signaller's head. Goslings reared with their parents began head-tossing during the hatching day. The number of signals performed by them peaked on the tenth day. In 86% of the observations (n=21) at least one family member followed a gosling which gave head tosses before walking or swimming. Human-reared goslings that were kept from adult geese did not develop head-tossing until they were exposed to other geese. We venture to speculate that visual signalling is in some way impaired if goslings are not reared with their parents at least for a short period.

The possible functional adaptations associated with these signals in Canada Geese inlcude: transmission of threat or warning to conspecifics; obtaining the attention of family members in order to synchronise their travel especially during the brood rearing stage; facilitating inconspicuous retreat from predators during flightless periods; and serving as a specialised system of communication for terrestrial and aquatic locomotion, as flight has great energetic demands.

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