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PABLO LUIS TUBARO, *Laboratorio de Fisiología del Comportamiento. Instituto de Biología y Medicina Experimental. Obligado 2490. 1428—Buenos Aires, Argentina.* *Received 3 June 1991, accepted 12 Oct. 1991.*

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Social organization in Snow Geese: family size and individual behavior.—Great importance has been given to the family and its role in goose and swan societies (Raveling 1970, Prevett and MacInness 1980, Scott 1980, Lamprecht 1986, Black and Owen 1989). The social hierarchy of wild geese may be based on the family (or social unit) rather than on the individual (Boyd 1953, Hanson 1953, Raveling 1970, Black and Owen 1989), and individual ranks may not be independent from each other. For example, if individual "A" obtains rank 1, no other individual can obtain that rank. Moreover, the ranks of unit members are dependent on each other, that is, a juvenile cannot obtain a higher rank than its father or mother. Therefore, if a family gander has a low rank, all the members of its family have low ranks. The assertion that the behavior and characteristics of the individuals comprising these social units is unimportant compared to the social unit has not been unequivocally demonstrated, however. Although it was first thought that the number of individuals in a unit was the major determinant of rank (Boyd 1953, Hanson 1953, Raveling 1970, Black and Owen 1989), Lamprecht (1986) found in Bar-headed Geese (*Anser indicus*) that the rank of a family is determined mainly or solely by the behavior of the gander. Furthermore, events happening during hierarchy formation may also influence the dominance status eventually attained by a family.

We determined the relative importance of the nature and size of the social unit on the one hand, and the characteristics and behavior of individual birds composing these units, on the other, in the establishment and maintenance of the nested hierarchy in Greater Snow Geese (*Chen caerulescens atlantica*). The present study was conducted at La Pocatière, 100 km northeast of Québec city, Canada, between May and August 1988. Geese were cannon-netted, sexed, and fitted with numbered plastic neck collars. Age was determined as: (1)

juvenile; <one-year-old (grey), and (2) adult-plumaged; >one-year-old (white). All 138 birds of a single catch were released in a covered enclosure and observed from a blind. Groups of related individuals, such as families and pairs, were determined by the tendencies of certain individuals to associate. Groupings were often confirmed by the performance of the triumph ceremony by members of a unit (Fischer 1965). Two similar captive flocks of 18 geese each were then formed. Each group was composed of nine social units as follows: a family of five (i.e., three juveniles and two adults), a family of three (two adults and one juvenile); a pair; two single, unrelated adult-plumaged birds (one male and one female), three single, unrelated juveniles, and a group of three juveniles without parents (JWP). The geese were weighed, and tarsus, culmen, and fat thickness on the breast, abdomen, and thigh were measured. Total fat reserves were calculated using Gauthier and Bédard's technique (1985). Primaries of both wings were clipped to render the geese flightless. Death of an adult female between capture and the beginning of the observation reduced the size of group B to 17. Two groups of 18 geese were released in adjacent enclosures of 20 × 20 m, separated visually. The observations were made from an elevated (5 m) blind located between the two enclosures, so that the two groups could be observed simultaneously by two observers. Geese were observed 6 h/day, beginning at sunrise, and continuous behavior sampling was used. Agonistic interactions were recorded on tape and transferred to computer. For each agonistic interaction, the identity of the opponents, their role (attacker or victim), their success (winner or loser) and the intensity of agonistic behavior were recorded. Intensity was divided into five levels (modified from Black and Owen 1987). The rank orders of individuals and social units were determined by calculating the percentage success (wins/total encounters × 100) (Black and Owen 1989). We also calculated an index of dominance (number subdominant/total number of geese × 100) (Lamprecht 1986) from a dominance matrix. The matrix also yielded Landau's linearity index (from 0, no linearity, to 1, perfect linearity) which enabled us to test for the permanence of the hierarchies (Landau 1951). The relationships between morphological measurements and rank were assessed within each group using Spearman rank correlations. SAS utility system was used throughout. We found that all members of a unit had adjacent ranks, and thus, had relatively similar dominance indices (Table 1) except for the pair of group A. This pair was formed of a successful and highly ranked male and of a submissive low ranked female (Table 1). We found that in group B, the large family dominated the small one, but in group A the large family was dominated by the small one and even by the male of the pair (Table 2). Furthermore, in group B, according to the dominance index, the pair was dominated by the lone adult male, although it had a lower percentage success (Table 2). Otherwise, single adults ranked behind pairs and juveniles (single and JWP) ranked lowest (Tables 1 and 2). Using the dominance index of each individual (Table 1) we tested if some of their morphological characters were associated with their rank. We found significant correlations between weight and rank and total fat reserve and rank for group B ($r_s = -0.72$ and -0.5: $P < 0.05$ df = 17 for weight and total fat reserves, respectively). Our results, as do those of Turcotte (1987), show that large families did not always dominate small ones and pairs. However, they are consistent with published work in showing that families and pairs dominate lone adults (Boyd 1953, Hanson 1953, Raveling 1970, Scott 1980, Lamprecht 1986, Turcotte 1987, Black and Owen 1989). If, as Lamprecht (1986) stated, the rank of a unit is mostly determined by the characteristics and behavior of the gander, the low aggressiveness of the males may explain the low ranks of the large family and of the pair. In group A, the male of the dominant unit, the family of three, was very aggressive (1469 attacks initiated) while that of the large family, which ranked third, was not (359 attacks initiated). In group B, according to the dominance index, the pair was dominated by the single adult male. In both instances, where the unit had a rank lower than expected, both males were meek while the females were attacking

TABLE 1

INDIVIDUAL RANKS IN TWO GROUPS OF CAPTIVE GREATER SNOW GEESE OBTAINED USING % OF SUCCESS (RANK 1) AND DOMINANCE INDEX (RANK 2)[a]

Status	Sex	Age	No. attacks	% Success	Rank 1	Dominance index	Rank 2
			Group A				
F3	M	A	1469	99.8	1	100	1
F3	M	J	1106	98.1	2	88.2	4
F3	F	A	1198	97.6	3	94.1	3
F5	F	A	688	71.1	4	64.7	7
P	M	A	511	70.1	5	94.1	2
F5	M	J	390	54.1	6	52.9	9
F5	M	A	359	52.4	7	76.5	5
F5	F	J	339	51.6	8	47.1	10
F5	M	J	309	45.1	9	58.8	8
P	F	A	212	42.3	10	64.7	6
SA	M	A	504	38.4	11	35.0	12
SA	F	A	273	32.9	12	35.0	11
JWP	F	J	242	27.8	13	18.0	15
JWP	F	J	122	16.7	14	24.0	14
JWP	M	J	120	16.0	15	29.0	13
SJ	M	J	126	15.1	16	12.0	16
SJ	M	J	69	4.9	17	12.0	17
SJ	F	J	0	0	18	0	18
			Group B				
F5	M	A	1857	100	1	100	1
F5	M	J	1830	100	2	87.5	3
F5	F	J	1511	99.5	3	81.3	4
F5	F	J	1298	99.2	4	75.0	5
F5	F	A	1468	98.7	5	93.8	2
F3	F	A	775	50.1	6	62.5	7
F3	M	J	702	49.2	7	56.3	8
F3	M	A	619	47.3	8	68.8	6
P	F	A	802	42.2	9	37.5	11
SJ	M	J	866	37.7	10	25.0	13
P	M	A	607	36.2	11	43.8	10
SA	M	A	518	33.5	12	50.0	9
SJ	M	J	398	26.9	13	31.0	12
JWP	M	J	67	4.8	14	6.3	16
JWP	F	J	64	4.6	15	12.5	15
JWP	M	J	59	3.6	16	18.8	14
SJ	F	J	27	2.0	17	0	17

[a] F5 = family of 5, F3 = family of 3, P = pair, SA = single adult, SJ = single juvenile, JWP = juvenile without parents, F = female, M = male, A = adult, J = juvenile.

TABLE 2

RANKS OF SOCIAL UNITS IN TWO GROUPS OF CAPTIVE GREATER SNOW GEESE OBTAINED USING % OF SUCCESS (RANK 1) AND DOMINANCE INDEX (RANK 2)

Status	% Success	Rank 1	Dominance index	Rank 2
		Group A		
Family of five	52.6	3	60	3
Family of three	98.6	1	100	1
Pair	59.1	2	80	2
JWP	20.6	5	20	5
Single adult	36.3	4	40	4
Single juvenile	6.9	6	0	6
		Group B		
Family of five	99.5	1	100	1
Family of three	48.9	2	80	2
Pair	39.4	3	40	4
JWP	4.3	6	0	6
Single adult	33.5	4	60	3
Single juvenile	25.1	5	20	5

more often (688 attacks for the female of the family of five against 359 for the male and 802 attacks for the female of the pair against 607 for the male, Table 1). Our results also suggest that the aggressiveness of the male, based on the number of interactions initiated, plays an important role in the rank of its unit and that unit size may not be as important as previously thought for the determination of rank. The lack of aggressiveness shown by some males may result in looser family bonds (Raveling 1970) and, consequently, in lower rank for its unit. However, our results do not show that aggressiveness of males is related to family size (Raveling 1970). The male of the family of five (in group A) was not very aggressive, although it had three juveniles, whereas the male of the family of three demonstrated high aggressiveness. Our results rather confirm that there is a large range of variation in aggressiveness by individual ganders regardless of unit size. Our results show that females and juveniles rank higher when they belong to a family or a pair than when they are alone. We might think that, when in family, females and juveniles acquire the rank of the male. They may acquire this higher rank because of the strong family cohesion and the help and motivation provided by the male in encounters, which allows them to be recognized by the victim or a potential attacker as being members of that male's family. However, the male may also have a lower rank when he is not with his family (Lamprecht 1986). Although Raveling (1970) mentioned the importance of the male in the success in rank order of a unit, all authors, with the exception of Lamprecht (1986), concluded that the rank of a unit is dependent upon unit size (Boyd 1953, Hanson 1953, Raveling 1970). Therefore, it would be interesting to test for the effect of the male on the rank of its unit. This could be done by comparing the ranks of a group of ganders (isolated from their family units) and those of their families (including the gander). The results from the correlation analyses indicate that tarsus and culmen length, which were used as predictors of body size, are not associated with rank. These results agree with those of Lamprecht (1986) who found

only low correlations between these factors and dominance. The relationship between weight and rank is highly variable. We found a significant correlation in group B but not in group A. The greater variability of weight in group B (c.v. = 11 and 15 for group A and B, respectively) can explain these results. This is consistent with published results, as some investigators found significant correlations (Scott 1980, Black and Owen 1989) while others found none (Lamprecht 1986). Since total fat reserve is partly dependent upon body mass, it comes as no surprise that it should also relate to rank. Thus, there is some evidence from our results that rank determination and dominance in Greater Snow Geese units is a summation of many factors, of which male aggressiveness seems to be uppermost. However, further experimentation needs to be done to evaluate the importance of the family on dominance.

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SYLVIE CLOUTIER AND JEAN BÉDARD, *Départ. de Biologie, Faculté des sciences et de génie, Univ. Laval, Ste-Foy, Québec, G1K 7P4, Canada.* (Present address SC: *Départ. de Psychologie, Univ. du Québec à Montréal, c.p. 8888, Montréal, Québec, H3C 3P8, Canada*). *Received 22 Jan. 1991, accepted 1 Oct. 1991.*