NEW WORLD SECTION

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Observations on habitat use, breeding chronology and parental care in Bristle-thighed Curlews on the Seward Peninsula, Alaska

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Results from an intensive survey in 1989 of one of the two known breeding localities of Bristle-thighed Curlews *Numenius tahitiensis* are reported. During the pre-nesting period birds confined most of their activity to two vegetation communities: shrub meadow tundra and low shrub/tussock tundra. During nesting more than half the Curlews seen were observed on shrub meadow tundra, whilst during brood rearing, use of low shrub/tussock tundra continued to decline in importance as birds attending young increased their use of sedge wet meadows. Despite extensive searches no nests were located; however, observations of broods indicated that nest initiation began around 25 May and that hatching occurred during the last week of June. Detailed observations are presented on the formation of four brood-groups, some of which held different combinations of unrelated adults or young. The adaptive significance of this unusual wader behaviour is discussed.

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INTRODUCTION

The Bristle-thighed Curlew *Numenius tahitiensis* nests only in remote mountains of western Alaska and winters on atolls throughout the central and south Pacific Ocean. In 1989 it was designated (54 FR 560) a Category 2 candidate for the United States Department of the Interior List of Endangered and Threatened Wildlife. This listing resulted from information from several co-ordinated studies begun since 1985 on the breeding grounds (McCaffery & Peltola 1986; Gill et al 1988), the fall staging grounds (Handel & Dau 1989), and the wintering grounds (Marks & Evans unpubl.; Gill & Redmond, unpub.).

Factors likely to affect the overall population and an assessment of its status are:

1) specific habitat requirements related to elevation and physiography, which may limit local distribution and density of breeding birds;
2) local and regional climatic factors, which may affect habitat availability and breeding distribution;
3) distribution and densities of avian predators, which may limit reproductive output over portions of the breeding range; and
4) introduction of exotic mammalian predators throughout much of the wintering range. These factors make assessment of the status of the population inherently complex. In addition, several unique, intrinsic behaviors of the species continue to challenge us and preclude or limit systematic efforts at learning even basic components of the species' life history.

In 1985 McCaffery & Peltola (1986) began the first study of nesting Bristle-thighed Curlews, in the mountains north of

Mountain Village at Curlew Lake, Alaska (Figure 1), the site of the only two previously reported nests of the species (Allen & Kyllinstad 1949, *in* McCaffery & Peltola 1986). In 1988 we began a survey of the distribution of Curlews on a second reported breeding area in the interior mountains of the Seward Peninsula (H. Springer *in litt.*; Kessel 1989). Based on results of this survey, we established a permanent study site in 1989 and began an intensive study of the breeding ecology of a second population of Curlews for comparison with McCaffery's ongoing research at Curlew Lake. This paper presents preliminary results of our research, focussing on breeding chronology, habitat use and parental behavior in Bristle-thighed Curlews nesting on the Seward Peninsula.

STUDY AREA

A permanent field camp was established in mid-May 1989 in the upper Kougarok River drainage, about 125 km N of Nome and 350 km N of McCaffery & Peltola's (1986) study area at Curlew Lake (Figure 1). The 93 km^2 site, hereafter referred to as Neva Creek, is centered near the confluence of Neva Creek and the Kougarok River. Rolling hills, ranging between 70 and 435 m elevation, and numerous drainages typify the Neva Creek area. The drainages are mostly covered with dwarf shrub and tussock tundra (Swanson *et al.* 1985; Kessel 1979, 1989) distributed in large expanses over hillsides according to elevation. A second, smaller study area, similar in habitat and topography to Neva Creek, was established at Coffee Dome, about 15 km S of Neva Creek (Figure 1).

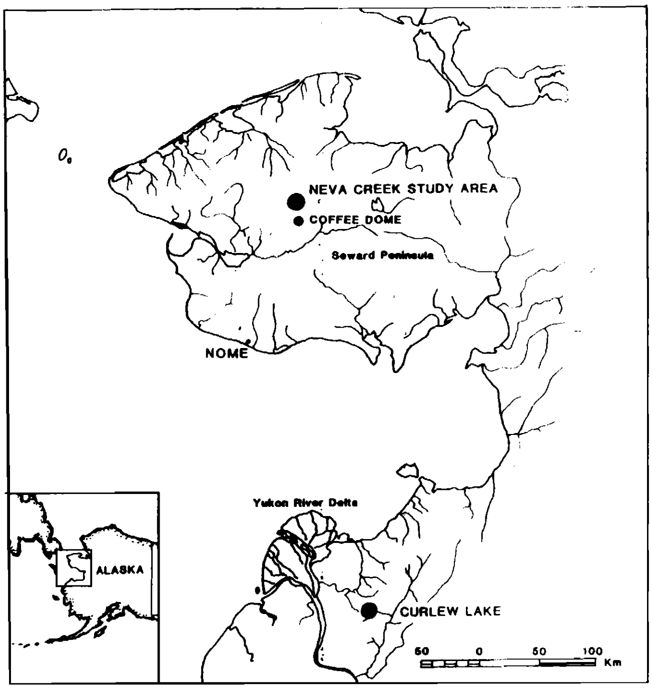


Figure 1. Western Alaska showing the location of the Neva Creek and Coffee Dome study areas in relation to Curlew Lake, which occur in the only two known breeding areas of the Bristle-thighed Curlew.

METHODS

Habitat availability and use

We mapped habitats using the classification described for the Seward Peninsula by Swanson *et al.* (1985). Boundaries of habitats were drawn from selected vantage points in the study area onto black and white enlargements (1:20 000 scale) of color-infrared (1:60 000 scale) photographs. We later ground-truthed these enlargements to verify habitat type. The amount of each habitat was measured from the 1:20 000 scale photographs using an electronic digitizing planimeter.

Use of habitats by Curlews during the pre-nesting (before 31 May) and nesting periods (1–25 June) was derived from point-count data collected along nine linear transects (each 1.5–6.5 km long; 37.5 km total length) replicated a varying number of times. Transects were plotted across gradients of topography and habitat to obtain a systematic sample of the area. Transects were separated by at least one drainage system and census points were spaced 500 m apart to minimize potential for duplicate counts of Curlews. At each census point observers recorded the number, behavior, and habitat of Curlews seen or heard during a 10 minute period within a circular plot of unlimited radius (Reynolds *et al.* 1980). During the brood-rearing period (after 26 June), a habitat class was recorded for every encounter of a brood during repeated searches through the study area. Habitat use was not recorded for adults unaccompanied by young during this period.

Distribution of territories

The distribution of territories was determined by mapping the locations of all: 1) displaying males; 2) territorial interactions; and 3) localized activity of Curlew pairs recorded during censuses and repeated traverses of the entire study area. The lack of auxillary markers on birds during the nesting period hampered recognition of individual birds and hence limited our efforts to define territorial boundaries.

Searches for nests and broods

We searched for nests by: 1) watching a suspected nesting area to detect an exchange of adults; 2) observing a member of a pair throughout the day to detect an exchange at the nest; and 3) dragging a rope through a suspected nesting area to flush an incubating bird. Broods were located by repeatedly traversing the study area on foot and watching and listening for adult Curlews exhibiting brooding behavior. Parents were captured when, in response to calls from their captured chicks or taped distress calls of other Curlew chicks, they flew close enough to be entangled in a mist net strung between two of us. Adults and one chick were given unique combinations of colored rings (up to four) while all other chicks were ringed non-uniquely with a single color to denote year class. Seven adults attending broods were also equipped with radio transmitters (after Dwyer 1972).

Broods were relocated at least once every three days either by radio telemetry or by searching near the area where we had last encountered them until the adults responded by our presence. Whenever broods were found we noted the location, number of chicks, habitat occupied, and identity of the attending adult(s) and their behavior towards us and natural predators. During this period adults with radios were relocated about daily and their location, habitat type occupied, presence of other species, and method of detection (radio, visual, or both) were similarly noted.

We sexed birds based on measurements of museum specimens (Gill & Handel unpubl. data), behavior and obvious within-pair differences in size, shape and color of the culmen. Generally, the member of the pair that was smaller with a narrower, darker, and more decurved culmen was considered to be the male. However, we know of one pair among eight at the Curlew Lake study site in which this sexual dimorphism was reversed (McCaffery *pers. comm.*).

RESULTS

Habitat availability and use

The Neva Creek study area is a mosaic of typical subarctic and arctic tundra habitats. Four communities as described by Swanson *et al.* (1985) represent the majority (97.3%) of land cover on the study area: low shrub/tussock tundra (*Betula nana, Empetrum nigrum, Ledum palustre, Vaccinum* spp., *Salix* spp.), mixed shrub thicket/tundra (*Salix* spp., *Betula nana,* and *Alnus crispa* over tussocks), tall shrubs (*Salix alaxensis,* typically in bands along water courses), and shrub meadow/tundra (many of the same species as low shrub/ tussock tundra but more prostrate and with varying amounts of bare ground). Also important to Curlews, but representing only a small fraction of the land cover of the area (<2.5%), were sedge wet meadow (*Carex aquatilis, C. bigelowii, Eriophorum* spp.) and lichen meadow (like shrub meadow/ tundra but confined to higher elevations and with more bare ground and lichens). Attributes of each of these major vegetation communities and the distribution of these communities over a typical drainage are depicted in Figure 2.

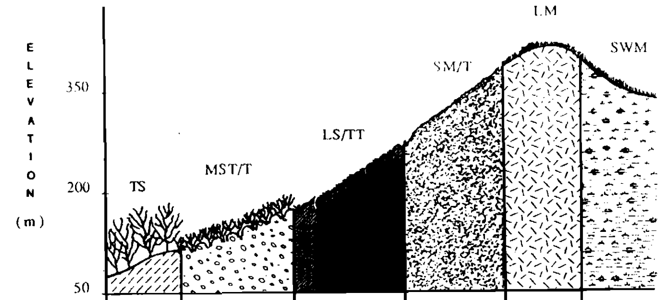
Habitat use was recorded for 51 Curlews on 65 point counts during the pre-nesting period, 86 Curlews on 446 point counts during the nesting period, and for 109 observations of broods during the brood-rearing period (Figure 3). During the course of the season Curlews exhibited a significant change in their use of habitats (p<0.0001, χ^2 = 33.33, df = 6). Throughout pre-nesting, birds confined most of their activity to two communities: shrub meadow tundra (33%) and low shrub/ tussock (47%).

The remaining 20% (10 birds) were seen in other habitats, including six birds on snow fields. During nesting, more than half of the Curlews observed were associated with shrub meadow/tundra, while use of low shrub/tussock decreased to about half of that recorded during the pre-nesting period (Figure 3). Use of low shrub/tussock tundra continued to decrease in the brood-rearing period as birds attending young increased their use of sedge wet meadows. Use of shrub meadow tundra during brood-rearing continued at about the same proportion as during nesting. Younger broods used habitats with a moderate level of tussocks and shrub cover, only favoring the more open lichen meadows and sedge wet meadows after fledging. Older broods restricted their movements to a particular mountain or drainage and generally favored habitats between 180 and 275 m elevation.

Nesting chronology and behavior

Aerial displays were detected on the day of our arrival (18 May) and were noted several times daily throughout May. Displays were usually centered over river drainages or on broad hillsides, and involved an adult male flying (with both flapping and gliding flight) in large oval patterns while making a complex series of calls. This display is not unlike the display flights of Whimbrels *N. phaeopus* and Long-billed Curlews *N. americanus* described by Skeel (1976) and Redmond (1984). Two populations and one attempted forced copulation were observed (27, 28 and 30 May, respectively) during the prelaying stage. Territorial interactions were recorded between the third week of May and the third week of June and usually involved two- and three-bird chases.

Twenty breeding territories were delineated on the study area, including one territorial bird for which a mate was never



	TS	MST/T	LS/TT	SM/T	LM	SWM
% of study area	16.4	28.1	39.4	13.4	0.8	1.6
Ht shrubs (m)	2.5-5.0	1.2-2.4	<0.4	<0.4	<0.4	<0.4
Presence of tussocks	no	yes	yes	no	no	no
Lichen sp. (%)	0-6	0-12	6-12	12-25	25-50	12-25
Grass sp (%)	12-25	6-25	25-50	12-25	6-12	25-50

Figure 2. A schematic drawing of the distribution and characteristics of the major habitat types on a typical drainage of the Neva Creek study area. Classification follows Swanson *et al.* (1985): TS = tall shrub, MST/T = mixed shrub ticket/tundra, LS/TT = low shrub/tussock tundra, SM/T = shrub meadow/tundra, LM = lichen meadow, and SWM = segde wet meadow.

definitely noted. Since territories were large (about 0.5–1.5 km²) and pairs were repeatedly located in the same areas, we feel confident that most territorial pairs were located.

As the number and intensity of breeding decreased, we began searching for nests. However, despite over 200 person-hours of searching, many by observers experienced with nesting waders, not a single Curlew nest was found during the 1989 season.

Brood-rearing

Our inability to find nests became an even larger enigma when over the same area during July we located 16 broods of Curlews (at one point we even fancied having discovered ovovivipary in birds). We also located two broods in the Coffee Dome area. Availing of the highly protective nature of adults towards their young, we eventually captured nine adult males, eight adult females, and 11 chicks. Seven of the adults were fitted with radio transmitters. Weights of captured chicks, when compared with data from the Curlew Lake study site (McCaffery unpubl. data), indicated that nest initiation at Neva Creek began around 25 May and that hatching occurred during the last week of June.

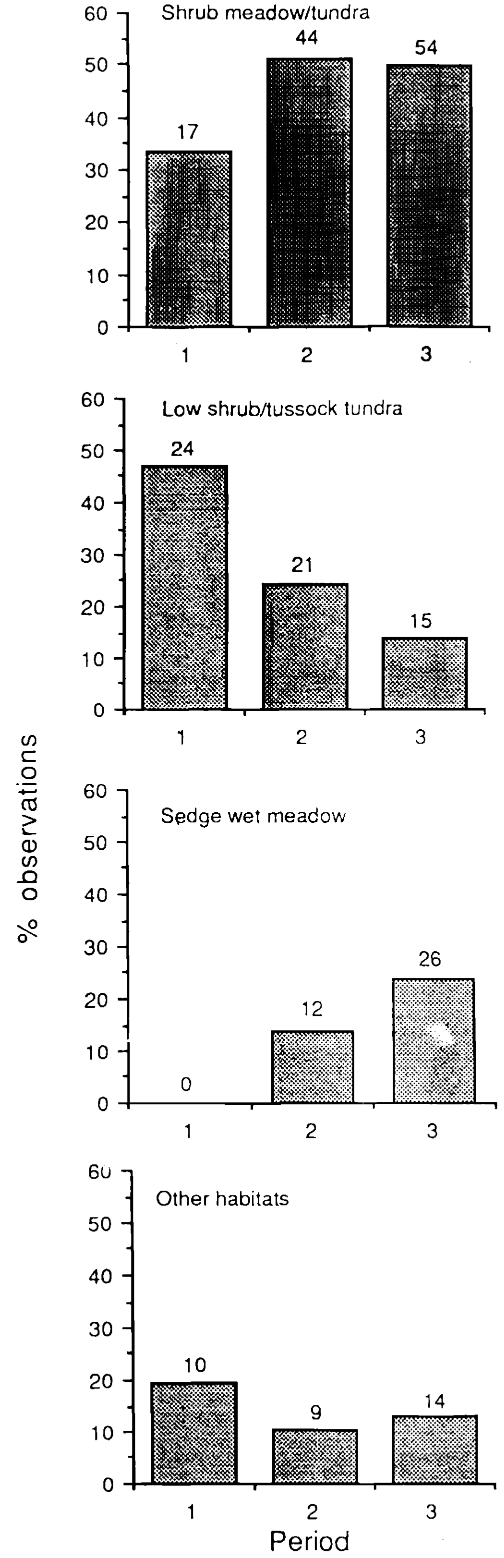


Figure 3. The percentage of Curlews associated with the major vegetative communities on the Neva Creek study area during the 1989 prenesting, nesting, and brood-rearing periods. Prenesting (period 1) is prior to 31 May, nesting (period 2) is between 1 - 25 June, and brood-rearing (period 3) is after 26 June. The number above each bar represents the total number of adults or broods observed in each habitat during each sampling period.

Female parents attended broods for a significantly shorter period of time than their mates (females = 12±9 days S.D., males = 26±8 days S.D., n=7, t=2.95, $p<0.02$), and most females (83%) left their brood before the young could fly. Most marked females appeared to leave the study area abruptly, although one female was seen on an adjacent mountain six days after leaving her young. After the females departed, males remained with the young for about 10–14 days.

During late July, when juveniles on the Neva Creek study area were two to three weeks old and just flying, several broods merged into groups that were attended by adults (Table 1). Three brood-groups formed on the Neva Creek study area and a fourth was located on the Coffee Dome study area (Table 1, Figure 4). The three brood-groups from Neva Creek were known to include young from a minimum of eight of the 18 broods (Table 1), but more likely involved eleven of the broods, based on observations of marked adults and young and on size differences among young. Another of the eighteen broods was attended independently by its parents for at least 23 days; however, their unmarked young may have joined brood-groups after the marked parents left the study area. We are unsure of the fate of the remaining six broods, some of which we suspect were depredated or had joined other brood-groups off the study area.

Each brood group was attended by 1–5 adults, which included seven of the nine uniquely marked males, only two of eight uniquely marked females, and at least four unmarked adults of unknown sex (Table 1). Attending adults were generally thought to consist of parents of one or more of the young within the brood-group, although this was impossible to verify for most individuals since only one chick had been uniquely ringed. There were several known instances, however, in which young were attended only by nonparental adults and other instances in which adults attended brood-groups that contained none of their own young.

The single uniquely marked chick was seen with brood-group 1 (Table 1) four times, was being attended by marked, nonparental adults on three of the four encounters. During these three encounters the marked male parent of this chick was recorded successively 0.8, 4.9, and 5.2 km away and was never observed with the chick after it had joined the brood-group. On the fourth encounter the chick was observed alone.

Another chick, which was not uniquely marked, was also recorded consistently in that same brood-group, and in one instance it was being attended by one marked pair and another marked male, none of which could have been its parents since none of their chicks had been marked. Its suspected male parent was recorded 1 km away at the time. In contrast, brood-group 2, which consisted of young from probably two but at most three different broods, was being attended by five adults from at least four different pairs, based on ringing. Thus, at least one adult had to have been parentally unrelated to any of the young. This brood-group was also consistently attended by an adult Whimbrel, which was acting “broody”, and an adult Bar-tailed Godwit *Limosa lapponica*, although no young of either species was seen (Table 1). Occurrence of Godwits in these brood-groups was not uncommon. In brood-group 1, a juvenile Bar-tailed Godwit unaccompanied by any adult Godwits was recorded during six of the first seven encounters of the group, and two to five juveniles and one adult Godwit (on one occasion) were associated with brood-group 3 during six of twelve encounters (Table 1). The brood-group at Coffee Dome, which consisted of two very different sized juveniles probably from two pairs, was the only brood-group that did not contain other species.

Lone broods and brood-groups were mobile and often moved several 100 m daily, but always remained associated with a particular mountain or drainage (Figure 4). Within any one group the members were never seen beyond 75-100 m of each other when feeding, and often all of them were within a few metres of each other when roosting.

Defense of brood-groups by adults, as measured by their response to our presence, varied both among groups and among individual adults, but generally decreased in intensity as the season progressed and young became more independent. The only two marked females known to attend the brood-groups usually exhibited very passive defense and left the study area four to five days after the first brood-group had been recorded. Defense by males was generally more intense. When we approached newly formed brood-groups, males generally mobbed us and continuously gave intense alarm calls, behaviors similar to those elicited during defense of individual broods earlier in the season. As brood-rearing progressed, defense behavior changed to flying in large circles around us and giving moderate alarm calls or to simply giving alarm calls from the ground. Finally, late in the season our presence elicited no defensive response from the attending adults (Table 1).

DISCUSSION

From our first year's effort two highlights stand out - our failure to find a single nest despite ample evidence that nesting did occur, and our observations of brood-groups. The former we have attributed to bad Curlew karma. The latter appears to be a rare phenomenon among waders.

Among the various types of post-hatch brood-amalgamations that have been reviewed by Eadie *et al.* (1988), the brood-groups we observed among Bristle-thighed Curlews seemed to be most similar to creches. Bédard & Munro (1976: 223) have defined creches as groups of any number of adult females and young, two or more of which are parentally unrelated. Such creches usually involve adult females tending nonflying young. Among Bristle-thighed Curlews, however, alloparental care of brood-groups involved primarily adult males attending several unrelated flying young transitioning to independence. Within shorebirds we are only aware of this phenomenon occurring in recurvirostrids (Burbridge & Fuller 1982: 215-216; Hamilton 1975: 89) where either both parents or adults of unknown sex cared for non-flying chicks. Instances of interspecific adoptions in shorebirds are more common (*in* Breiehagan 1984), but usually involve a single brood with adult(s) that has incorporated into it one or two chicks of another species.

Current hypotheses regarding the evolution of brood amalgamations among different avian species center around how young adults, and non-attending adults may benefit (see Eadie *et al.* 1988, and Kehoe 1989 for reviews). Although we were unable to test any hypotheses during 1989 because of the paucity of uniquely marked adults and young, our general observations suggest possible advantages for this phenomenon in Bristle-thighed Curlews.

At Neva Creek adults attending young were generally aggressive towards both humans and potential avian predators (especially Common Ravens *Corvus corax* and Parasitic Jaegers *Stercorarius parasiticus*), approaching them. This aggression usually culminated with the adults mobbing the potential predator, although the frequency of mobbing decreased during the brood-rearing period. Predator densities were low and interactions with Curlews were few during 1989, which had a record late spring and probably precluded some predators from nesting. The markedly higher abundance of Short-eared Owls *Asio flammeus* and Parasitic Jaegers on the study area in 1988 (Gill unpubl. data), however, suggests that avian predators may be a much greater threat to Curlews during years with earlier springs.

Merging of broods may also provide a transition phase for parents between intensive defense of young during early brood-rearing and final abandonment of independent young whilst assuring the offspring's continued defense from predators but allowing the departing adults to recover resources depleted in breeding (*in* Eadie *et al.*1988) with a minimum of energetic parental investment. This behavior may play a key role in enabling adults to build up sufficient lipid reserves on the staging grounds on the Yukon Delta (Handel & Dau 1988) so they can complete their migration to wintering grounds in the central and south Pacific Ocean. Early departure by adults may also benefit young by decreasing competition for food on the breeding grounds (Pitelka *et al.* 1974).

Juveniles may also form brood-groups incidentally as broods coalesce around limited food resources (Savard 1987). Curlews are known to depend heavily on berries, especially *Vaccinium vitis-idaea, Rubus chamaemorus, and Empetrum nigrum,* during late July and August (Gill unpubl. data; McCaffery pers. comm.). Seasonal changes in habitat use recorded at Neva Creek may be related to availability and selection of different foods, with Curlews moving from the wetter low shrub/tussock tundra early in the season, where arthropods are an abundant, likely food, to the drier shrub meadow/tundra and wet meadows where berries become abundant later in the summer during brood-rearing. Defense of newly hatched young, however, may be aided by use of

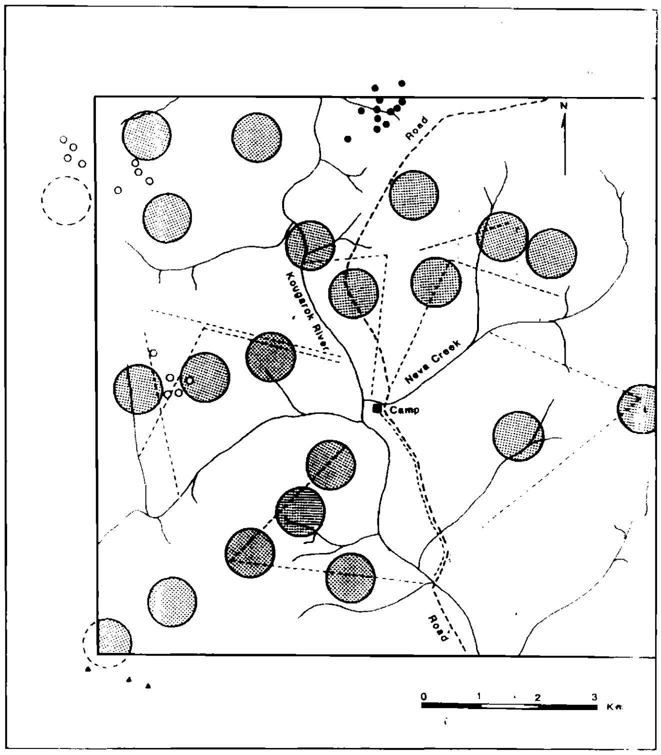


Figure 4. The distribution of transects (narrow dashed lines), approximate centers of nesting territories (large, shaded circles), and areas used by brood-groups (small symbols) associated with the Neva Creek study area (inset) during 1989. Repeated sightings of brood-groups 1, 2, and 3 (see Table 1) are shown by small open circles, small dark triangles, and small dark circles, respectively.

Table 1. Composition of brood-groups observed on the Neva Creek (#1-3) and Coffee Dome (#4) study areas during 1989.

		Minimum	# Adults[3]		Adult	
Date	# Young[1]	# Broods[2]	Marked	Unmarked	Behavior[4]	Other Species in Groups[5]
Group 1						
7/27	11	3	2 m, 1 f		Flying	1 BTGO Juv.
7/28	9	3	2 m		Flying	1 BTGO Juv.
7/29	10	3	1 m		Mobbing	1 BTGO Juv.
7/30	10	3	1 m, 1 f		Mobbing	1 BTGO Juv.
7/31	10	3	1 m		Calling	-
8/3	7	2	2 m		Calling	1 BTGO Juv.
8/5	10	3	2 m		None	1 BTGO Juv.
8/6	12	3	1 m		Calling	0
8/7	12	3	2 m		None	-
8/8	12	3	2 m		None	0
8/10	10	3	2 m		None	0
8/11	9	3			-	0
8/12	1	1			-	0
Group 2						
7/29	2	1	1 m, 1 f	3 ?	Mobbing	1 WHIM Ad. (Juv. ?), 1 BTGO Ad.
7/31	3	2*	1 m, 1 f	3 ?	Calling	1 WHIM Ad. (Juv. ?), 1 BTGO Ad.
8/1	1	1			-	1 WHIM Ad.

Table 1. Continued.

		Minimum	# Adults[3]		Adult	
Date	# Young[1]	# Broods[2]	Marked	Unmarked	Behavior[4]	Other Species in Groups[5]
Group 3						
7/27	5	2	1 m		Mobbing	2 BTGO Juv.
7/29	4	1	1 m		Flying	4 BTGO Juv.
7/30	5	2	1 m		Mobbing	1 BTGO Ad., 4 BTGO Juv.
7/31	-	-	1 m		Mobbing	-
8/1	-	-	1 m		Flying	-
8/2	5	2	1 m		Mobbing	5 BTGO Juv.
8/3	-	-	1 m		Flying	-
8/4	5	2	1 m		Flying	5 BTGO Juv.
8/5	1	1	1 m		Flying	0
8/7	3	1			-	2 BTGO Juv.
8/10	4	1			-	0
8/11	4	1			-	0
Group 4						
7/31	4	2*	1 m	1 ?	Calling	0

[1] Number of young seen; - = adult exhibited brood behavior but no young were seen.

[2] Minimum number of broods present assuming 4 young/brood, * = minimum of 2 broods present based on different sizes of young; - = adult exhibited brood defense behavior but no curlew young were seen.

[3] Number and sex of unmarked and marked adults associated with the brood-group; m = male, f = female, ? = unknown sex.

[4] None = no response; Calling = moderate alarm calling from ground; Flying = moderate alarm calling and flying around observer; Mobbing = intense alarm calling and mobbing observer; - = no adults present.

[5] BTGO = Bar-tailed Godwit; WHIM = Whimbrel; Ad. = adult; Juv. = juvenile.; - = adult curlew exhibiting brood behavior but no young of other species were seen; 0 = no other species thought to be with brood-group; ? = adult behavior indicated young were present.

low shrubs as protective cover from avian predators, but once young are older they move to more open meadows and survival may be enhanced by the formation of brood-groups. Competition for brood-rearing areas rich in foods and decreased predation mechanisms may work together, allowing juveniles to spend more time feeding and less time vigilant (Abramson 1979).

Attending adults may likewise benefit if their young suffer lower predation through a simple dilution effect from the addition of non-parental young to the group (Eadie & Lumsden 1985) or through a selfish-herd mechanism (Hamilton 1971) whereby 'foster' young are displaced to the periphery of the group. Additionally, kinship benefits could be accrued if an attending adult could enhance the survival of related young. This seems plausible since the species has high breeding site fidelity (McCaffery *pers. comm.*) and potentially strong natal philopatry, as exhibited by its two other North American congeners (Redmond & Jenni 1982; Skeel 1983).

STUDIES DURING 1990

Through the return of marked individuals from the 1989 season and an expanded color-marking and telemetry effort during 1990, we will focus studies on population demographics (territory size, habitat requirements, productivity, annual survival, etc.) and on the phenomenon of alloparental care of brood-groups. We would particularly like to hear from other researchers concerning their observations of and thoughts on this phenomenon in shorebirds (correspondence to R.E.G.).

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POSTSCRIPT

Alas, Bristle-thighed Curlews on the Seward Peninsula are not ovoviviparous. During the 1990 season we found six nests on our study area. We also captured and individually marked 21 adults and 20 juveniles. Young Curlews again formed creches on the area, the largest of which contained 22 juveniles, representing a minimum of six broods. Now that we have at least one member of each pair marked on the study area (totaling 37 individuals), it will be much easier for us when we return to the study area in 1991 to address many of the questions raised in this paper.