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GONADAL CYCLE OF GRAY GULLS, *LARUS MODESTUS*, IN NORTHERN CHILE

Marcos A. CIKUTOVIC, Carlos G. GUERRA and Lloyd C. FITZPATRICK

INTRODUCTION

The Gray Gull, *Larus modestus*, is abundant on the west coast of South America from 0° to 40°S. Lat. (Goodall *et al.*, 1945; Philippi, 1964; Howell *et al.*, 1974). During the breeding-nesting season (September-February) Gray Gulls congregate on the beaches of northern Chile, but do not nest there (Murphy, 1936; Goodall *et al.*, 1945; Howell *et al.*, 1974; pers. obs.). Instead they fly to the interior of the barren Atacama Desert, nesting in widely dispersed colonies between 35 and 100 km from the coast (Guerra *et al.*, 1988b). The only reported nesting sites for *L. modestus* are in the Atacama (see Howell *et al.*, 1974; Howell, 1982; Guerra and Cikutovic, 1983). As early as September Gray Gulls begin flying to the desert, presumably to establish nesting territories (Guerra *et al.*, 1988a). Prior to laying, pairs make daily round trip foraging flights to the coast, but afterwards one member tends the nest while the other forages (Howell *et al.*, 1974; Howell, 1982; Fitzpatrick *et al.*, 1988a). According to Howell *et al.* (1974) and observations by Guerra *et al.* (1988a) laying is asynchronous among years, beginning as early as November (see Goodall *et al.*, 1945) and extending into February. During a given year, laying is asynchronous within colonies Guerra *et al.* (1988); eggs, chicks and fledglings can be present in the nesting site, and recruits on the beaches at the same time.

Though some aspects of the breeding biology of *L. modestus* including the seminal work by Howell *et al.* (1974; see also Goodall *et al.*, 1945; Howell, 1982; Cikutovic and Guerra, 1980, 1985; Guerra and Cikutovic, 1983) nothing concerning its gonadal cycle appears in the literature. Here we describe annual gonadal cycles for both sexes of a *L. modestus* population located at Antofagasta, Chile (23°41'S. Lat.; Fig. 1), and relate them to behavioral observations and photoperiod.

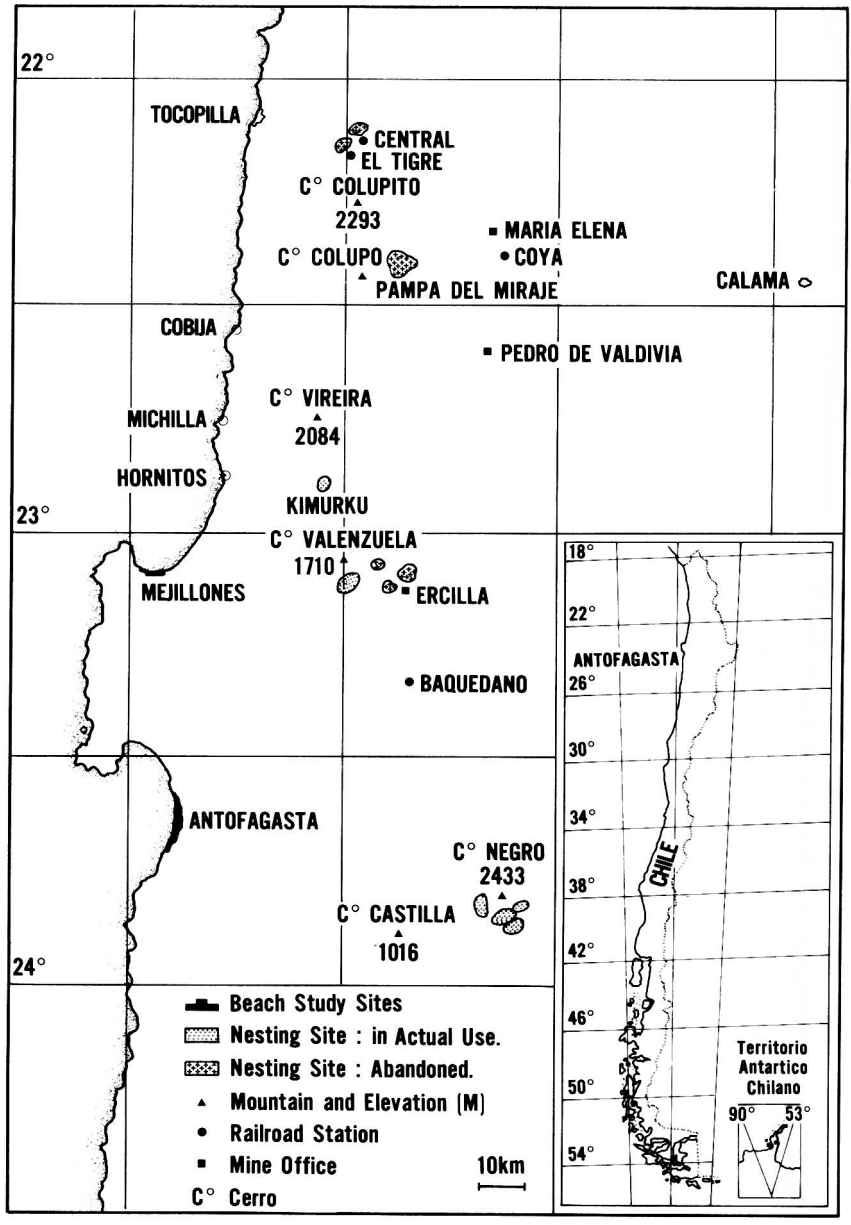

Fig. 1. Map of northern Chile showing collecting sites for Gray Gulls used in the study and nesting sites in the Atacama Desert.

MATERIALS AND METHODS

Adult gulls of both sexes were collected monthly during 1979-1980 from the rocky beaches near Antofagasta (Fig. 1). Adults are readily distinguished throughout the year from recruits and one-year-old juveniles by their respective plumages. Specimens were returned immediately to the laboratory, weighed and measured morphometrically. Ovaries and testes were removed, weighed and prepared for histological examination by standard techniques (*i.e.*, fixation in Dubosq-Brasil, dehydration, clearing and histological paraffin embedding; 5-6 µm sections stained with haematoxylin-eosin or haemotoxylin-periodic acid Shiff). Ovarian follicle diameters were measured with an ocular micrometer, classified by size and presence of vitelline. Diameters of the testes were measured, as were diameters of seminiferous tubules and height of germinal epithelium after histological preparation. Presence of spermatozoa in the lumen of the seminiferous tubules was noted. A gonadal somatic index (GSI) was calculated for males (GSI = $\overline{X}$ diameter of both testes/wing length) and females (GSI = $\overline{X}$ diameter of the six largest follicles/wing length). Wing length was used because it is one of the most consistent morphometric characters in *L. modestus* (Fitzpatrick *et al.*, 1988b). The six largest follicles were used because females seldom begin to yolk more than six.

RESULTS AND DISCUSSION

Distinct annual patterns in gonads of both sexes occurred during 1979-1980 (Tables 1-3, Fig. 2). Table 1 presents monthly variation in GSI's, Table 2 and 3 present measurements for ovarian follicles and testes, respectively. Fig. 2 illustrates the cycles, comparing diameters of follicles and seminiferous tubules, and indicating when spermatozoa are present in the tubules, and when follicles containing yolk and oviducal eggs are found. In general, indicators of gonadal activity were highest during the breeding-nesting season (November-January). In females, GSI was highest during December whereas male gonads peaked approximately one month earlier. Gonads of both sexes showed minimal size or activity after the breeding-nesting season (February-July). Gonadal activity began in August-September when gulls were congregating on the beaches, initiating courtship and forming pairs. We observed gulls beginning to fly to the desert in September and copulating from November to December in both 1979 and 1980.

Our data on gonadal activity accord closely with personal observations and those of others (*e.g.*, Moynihan, 1962; Howell *et al.*, 1974) of courtship, copulation, initiation of desert flights and presence of eggs and/or chicks at nesting sites. Peak gonadal activity of males coincided with observations of courtship consummation on the beaches. Gonadal activity and attendant reproduction during 1979-1980 coincided with maximal photophase (13.6 h;

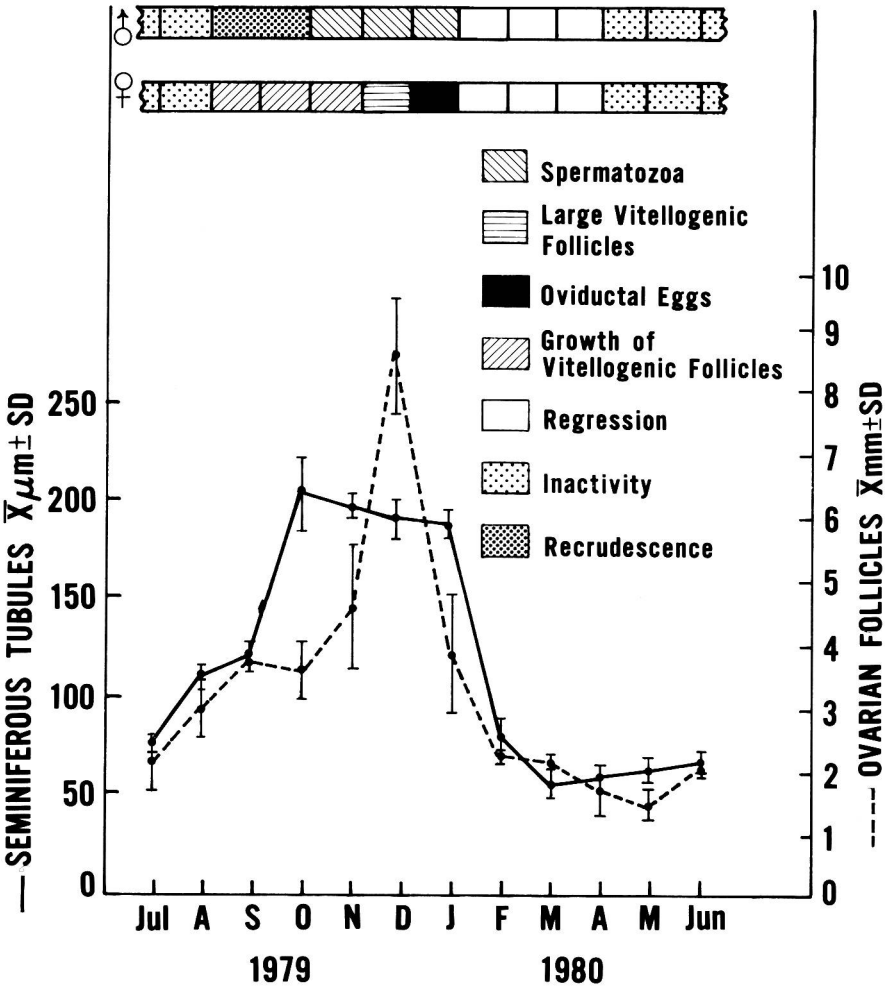

Fig. 2. Annual variation in diameters of seminiferous tubules (μm) and ovarian follicles (mm) of Gray Gulls, *Larus modestus*, during 1979-1980.

December) and attainment of mean summer-high air temperature (20.8°C; December-February). Thus, *L. modestus* appears to cue its gonadal cycle and subsequent reproduction on increasing photophase ($r = 0.941$, $P = 0.005$ for males and $r = 0.806$, $P = 0.053$ for females), and temperature. That pattern is opposite of Franklin's Gull, *L. pipixcan*, which winters in Chile, but nests in the northern hemisphere (Cikutovic and Guerra, 1985).

Table 1. **Annual variation of the gonadal somatic index of Gray Gulls, *Larus modestus*, during 1979-1980*.**

	Females			Males		
Month	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Oct. 1979	5	10.10	1.64	6	1.60	0.05
Nov.	4	13.30	3.14	4	2.17	0.06
Dec.	5	25.20	6.80	3	1.99	0.06
Jan. 1980	3	11.70	3.35	4	1.91	0.07
Feb.	3	6.80	0.87	5	1.13	0.10
Mar.	4	6.30	0.58	4	0.79	0.06
Apr.	3	5.20	1.28	4	0.78	0.08
May	5	4.70	1.17	5	0.82	0.05
Jun.	4	6.90	0.10	4	0.64	0.10
Jul.	5	6.50	1.89	5	0.61	0.05
Aug.	5	8.50	1.51	4	1.13	0.04
Sep.	5	11.20	1.64	5	1.04	0.06

* $\overline{GSI}$ females = [($\overline{X}$ diameter of six largest ovarian follicles ÷ wing length) x 10^3]
$\overline{GSI}$ males = [($\overline{X}$ diameter of both testes ÷ wing length) x 10^3]

Table 2. **Annual variation of the ovarian follicles of Gray Gulls, *Larus modestus*, during 1979-1980.**

		Follicle Diameter*	
Month	N	$\overline{X}$ mm	SD
Oct. 1979	5	3.45	0.64
Nov.	4	4.60	1.07
Dec.	5	8.51	1.30
Jan. 1980	3	3.90	1.10
Feb.	3	2.30	0.25
Mar.	4	2.20	0.20
Apr.	3	1.80	0.44
May	5	1.60	0.36
Jun.	4	2.32	0.06
Jul.	5	2.20	0.62
Aug.	5	3.00	0.65
Sep.	5	3.80	0.12

* $\overline{X}$ of the six largest follicles.

Table 3. **Annual variation of testicular parameters of Gray Gulls, *Larus modestus*, during 1979-1980 *.**

	Testes Diameter		Seminif. Tubules Diameter		Germinal Epithelium	
	X(mm)	SD	X(m)	SD	X (m) height	SD
Oct. 1979	5.60	0.22	201.51	18.30	78.42	9.02
Nov.	7.63	0.38	195.30	4.54	71.25	3.55
Dec.	7.00	0.22	188.37	10.72	68.15	5.61
Jan. 1980	6.80	0.33	185.67	12.13	65.75	8.44
Feb.	3.90	0.43	77.87	9.52	24.50	4.15
Mar.	2.80	0.26	54.12	8.87	21.32	2.01
Apr.	2.73	0.30	58.22	5.03	18.37	2.40
May	2.90	0.22	60.75	6.72	21.07	2.55
Jun.	2.23	0.31	67.00	4.67	23.12	2.67
Jul.	2.10	0.18	71.62	3.87	21.57	2.46
Aug.	3.90	0.19	107.50	5.44	40.00	3.53
Sep.	3.74	0.27	116.52	6.12	39.25	2.25

* N = same as in Table 1

The among-year asynchrony of reproduction reported by Howell *et al.* (1974) and observed by us may be related to food availability (Guerra *et al.*, 1988a). The within breeding-nesting colony asynchrony of laying is more difficult to explain, but nest-site predation may be a factor (Guerra *et al.*, 1988b). Females begin yolking six follicles, but only one-two are generally laid at a time. Howell *et al.* (1974) reported the average clutch size for *L. modestus* was 1.55 at the now-abandoned (see Devillers and Terschuren, 1976; pers. obs.) Colupo colony. Guerra *et al.* (1988a) found mean clutch sizes in the Kimurku-Valenzuela and Cerro Negro colonies (Fig. 1) of 1.25 and 1.45, respectively. We believe that six follicles are "readied" to replace egg-chick mortalities which are related to predation or physical stringencies of the Atacama or both.

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SUMMARY

Gonadal cycles of male and female Gray Gulls, *Larus modestus*, are described and related to their seasonal reproductive behavior in northern Chile. Nesting and laying, which occur between November and January, are asynchronous within and among years, presumably related to food availability and/or predation pressure.

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SAMENVATTING

De gonadencyclus van mannelijke en vrouwelijke Grijze Meeuwen, *Larus modestus*, in noord-Chili worden beschreven en gecorreleerd naar hun seizoensgebonden voortplantingsgedrag. Nestbouw en eileg gebeuren tussen november en januari en zijn asynchroon binnen éénzelfde en tussen verschillende jaren. Waarschijnlijk houdt dit verband met de beschikbaarheid van voedsel en/of met predatiedruk.

RESUME

Les cycles gonadaux des femelles et mâles de Goélands gris, *Larus modestus*, sont décrits et rapportés, pour le nord du Chili, à leur comportement reproductif saisonnier. La nidification et la ponte, qui se déroulent de novembre à janvier, sont asynchrones et d'une année à l'autre et endéans une même année. Sans doute ce fait est-il lié à la disponibilité de la nourriture et à la pression des prédateurs.

Marcos A. CIKUTOVIC, *Departamento de Ciencias Biologicas, Facultad de Ciencias de la Salud, Universidad de Antofagasta, Antofagasta, Chile.*

Carlos G. GUERRA, *Instituto de Investigaciones Oceanologicas, Universidad de Antofagasta, Antofagasta, Chile.*

Lloyd C. FITZPATRICK, *Department of Biological Sciences, University of North Texas, Denton, Texas 76203, USA*

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