THE TIME OF FIRST RETURNS TO LAND BY CORY'S SHEARWATER *CALONECTRIS [DIOMEDEA] BOREALIS*[1] ON SELVAGEM GRANDE DURING THE BREEDING PERIOD

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Mougin J.-L., Jouanin Chr. & Roux F. 2002. The time of first returns to land by Cory's Shearwater *Calonectris [diomedea] borealis* on Selvagem Grande during the breeding period. Atlantic Seabirds 4(2): 63-72. *The time of first returns to land within each attendance cycle by Cory's Shearwater* Calonectris [diomedea] borealis *on Selvagem Grande (30°09'N, 15°52'W) is negatively correlated with the number of birds that will come to land in the evening. However, the mean time of first returns for each attendance cycle shows no significant variation from May to September. The Cory's Shearwaters of Selvagem Grande are partly diurnal for at least part of their breeding cycle, in contrast to their conspecifics at other Mediterranean and Atlantic breeding localities. This behaviour may originate from when the size of the breeding population was very large, before its overexploitation and depredations in the 1960s and 1970s, and also linked to the lack of diurnal predators.*

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INTRODUCTION

Of the 60 or so acknowledged species of Procellariids, only about one tenth are diurnal. Cory's Shearwaters *Calonectris diomedea*[2] are usually nocturnal, and during the breeding season come to land after sunset to display at almost all the breeding localities in the Mediterranean and Atlantic (Bannerman 1914; Lockley 1952; Mallett & Coghlan 1964; Winthrope 1973; Servent 1987). The population of Selvagem Grande (30°09'N, 15°52'W), the largest of the Portuguese Selvagens Islands, situated between Madeira and the Canary Islands, is atypical in that its activities are partly diurnal, the first returns to land of the birds occurring before sunset during some summer weeks.

Having spent the boreal winter in the southern hemisphere, Cory's Shearwaters return to Selvagem Grande, as well as the other breeding localities, at the end of February and beginning of March. Eggs are laid at the end of May/beginning of June and, on average 54 days later, hatch during the second fortnight of July. Chicks, no longer brooded after a few days, are left alone in the nesting burrow; their period of growth is about 95 days. The fledglings leave the colony with the adults at the end of October and beginning of November (Zino 1971; Zino *et al.* 1987).

Table 1. Parameter estimates of the multiple regression model used to assess the contribution of bird numbers, date and sunset time in explaining the time of the first returns to land of Cory's Shearwaters on Selvagem Grande.

Tabel 1. Parameters van het multiple regressiemodel dat gebruikt werd om de invloed te schatten van aantallen, datum en het tijdstip van zonsondergang bij het verklaren van het tijdstip van terugkeer van Kuhls Pijlstormvogels op Selvagem Grande.

Variables	Coefficient	*t*	*P*
Numbers	-1.252	-8.03	0.000
Date	0.141	0.89	0.379
Sunset time	-0.025	-0.09	0.932

Visits made by the adults to the colonies of Selvagem Grande - both sexes together during the pre-egg period but separately during incubation and chick rearing - show daily variations in both the number of birds and the time of the first returns; the number of visiting birds varies regularly between a minimum and a maximum according to a sinusoid, the half-period of which is 5 days (Jouanin *et al.* 1989; Mougin *et al.* 2000). In this paper, we attempt to discover precisely the time of the first returns during the whole breeding period and the factors that influence it.

METHODS

Data on the time of return to land of the birds of Selvagem Grande were collected in a subcolony of about 100 pairs during three 3-week visits (May 1991, June-July 1988, September 1993). Birds present on land were counted daily at intervals of 15 mins. between the first and the last return. A torch was used when necessary. Casual observations made in June and July in previous years showed no important differences from the 1988 data, so we feel confident that the use of data spread over three years might allow seasonal comparisons.

We used multiple regression to assess the contribution of various factors in explaining variation in the time of the first returns to land, chi-square to test the differences in the distribution of returns relative to sunset during the three periods studied, Pearson's correlation to investigate the relationship between the number of birds coming ashore and the time of the first returns, and analysis of variance to compare the average number of birds coming ashore per unit time during the three periods studied. Means are presented ± SD.

RESULTS

Factors influencing the time of the first returns A multiple regression with the time of first returns as dependent variable and date, numbers of birds and

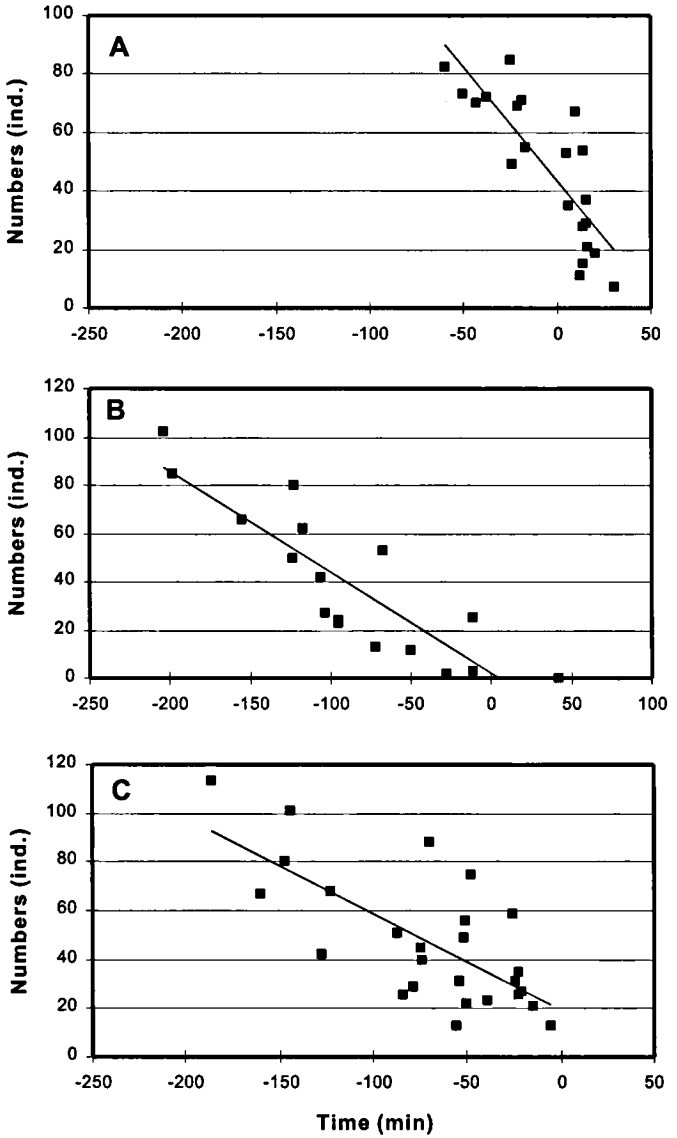
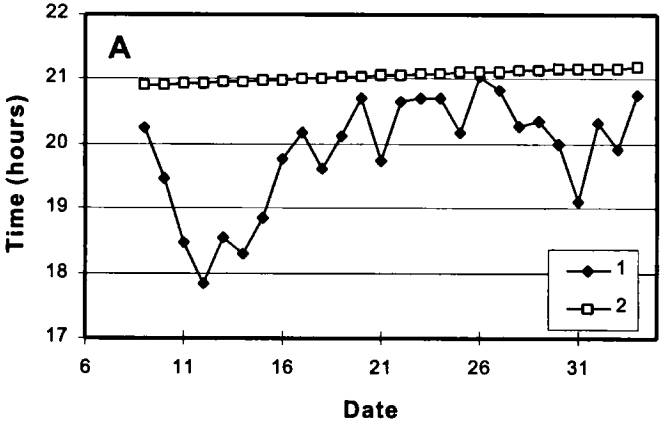


Figure 1. Time of the first returns to the colonies as a function of the number of birds present. A: May; B: June-July; C: September. 0 = sunset time.
Figuur 1. Tijdstip van terugkeer in de kolonie als functie van het totaal aantal arriverende vogels. A: mei; B: juni-juli; C: september. 0 = zonsondergang.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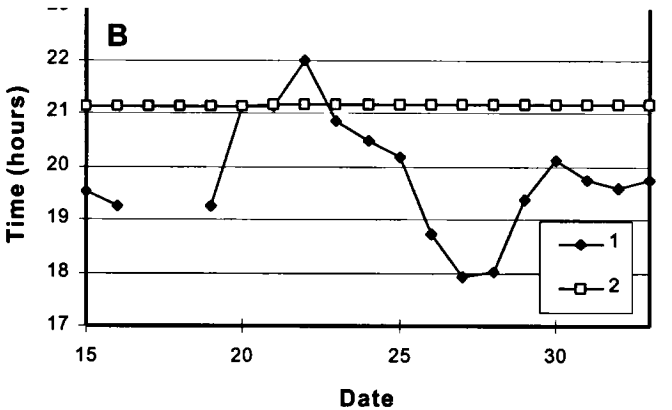
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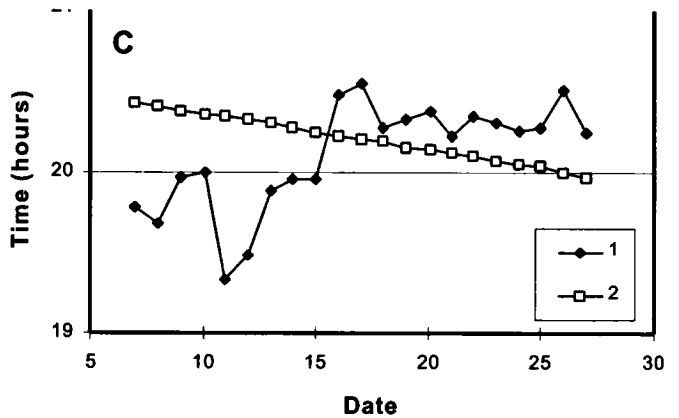
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Opposite page: Figure 2. Time of the first returns to the colonies as a function of date and sunset time. 1: time of the first returns; 2: sunset time. A: May; B: June-July; C : September. The time between 17 and 27 May corresponds approximately to the pre-laying exodus.

Tegenoverliggende pagina: Figuur 2. Tijdstip van terugkeer in de kolonie als functie van datum en het tijdstip van zonsondergang. 1: tijdstip van terugkeer, 2: zonsondergang, A: mei; B: juni-juli; C: september. De periode van 17-27 mei valt ongeveer samen met de 'pre-laying' exodus van Kuhls Pijlstormvogels.

sunset time as independent variables revealed that only bird numbers were important, explaining 50.5% of the variation in the dependent variable (Table 1). Figure 1 shows a significant correlation between numbers and time of first returns during the three periods studied (respectively $r_{26} = -0.687$, $P < 0.001$ for May, $r_{17} = -0.873$, $P < 0.001$ for June-July and $r_{21} = -0.759$, $P < 0.001$ for September).

No correlation exists between the time of first returns and date ($r_{64} = 0.169$, n.s.). The average time of the first returns was 19.54 hr ± 48 min ($n = 64$), the range of variation between earliest and latest first returns being particularly large in June-July. The average interval between first returns to land and sunset varied between May and September (Fig. 2). During the pre-laying exodus, the exceptional scarcity of the birds was associated with unusually late first returns - only 43 ± 25 min ($n = 10$) before sunset. With this exception, the first returns until July occured on average 85 ± 61 min ($n = 32$) before sunset, with large daily variations (coefficient of variation: 71.8%). From July onwards, the interval steadily decreased. During the second week of September, the first returns were observed 25 ± 23 min ($n = 9$) before sunset, but 12 ± 5 min ($n = 12$) after sunset during the third and fourth weeks. The first returns, which always occurred before sunset at the end of the pre-egg stage and during incubation and the beginning of chick rearing, were therefore observed after sunset during the last weeks of chick rearing.

Timing of returns Figure 3, based on counts performed at 15 min intervals, shows monthly differences not so much in the time elapsed between the first and last return and thus in the average rate of returns ($F_{2, 35} = 0.64$, n.s.) but in the distribution of returns relative to sunset time ($\chi^2 \geq 36.6$, $n \geq 14$, $P < 0.01$). The birds returned to their colonies regularly and slowly in June-July, mostly before sunset (21.18 hr on average). In May, they lingered at sea long after the return of their earliest conspecifics before retr\urning slowly, mostly after sunset (21.04 hr), the last birds being particularly aggregated. Lastly, in September, the returning birds were grouped after sunset (20.12 hr), the earliest birds returning swiftly and the later ones much more slowly, the reverse of the pattern in May.

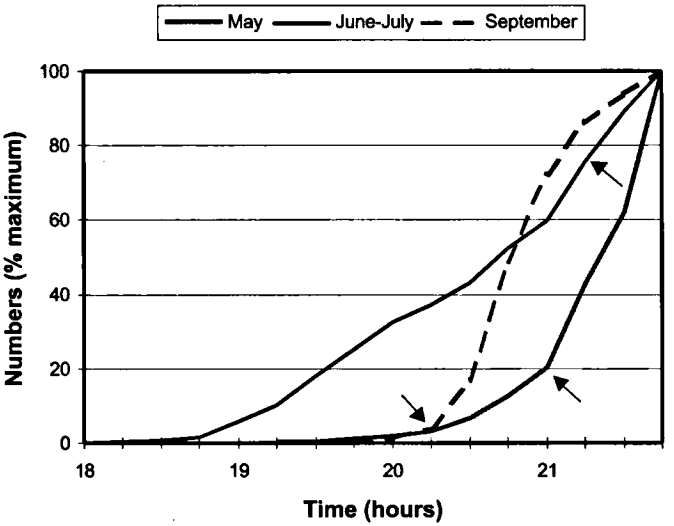

Figure 3. Timing of the returns to the colonies as a function of date. The arrows indicate the time of sunset.
Figuur 3. Tijdstip van terugkeer in de kolonie als functie van de datum. De pijlen laten het tijdstip van zonsondergang zien.

Thus, 65.8% of the birds returned to their colonies before sunset in June-July, 13.2% in May and 3.8% in September ($\chi^2_2 = 1180.2$, $P < 0.01$). In fact, 6.6% returned before sunset by mid September and none after this.

DISCUSSION

The reasons that there exists a strong relationship between the numbers of arriving birds and the time of first arrivals on Selvagem Grande, in contrast to other Cory's Shearwater colonies, are not clear. Nor is it known why, during some summer weeks, the first arrivals (but never all of them) are diurnal on Selvagem Grande but are not diurnal elsewhere (Hartert & Ogilvie Grant 1905; Bannerman 1914; Lockley 1952; Mallett & Coghlan 1964; Fernandez 1979; Thibault 1985; Martin *et al.* 1991).

Various hypotheses have been suggested to account for the birds' diurnal habits including habitat structure, availability of prey and predator avoidance (Granadeiro *et al.* 1998; Klomp & Furness 1992). Even if a disturbed

habitat is likely to discourage nocturnal behaviour, many birds are in fact nocturnal on Selvagem Grande and besides, the habitat here is relatively undisturbed. Similarly, the availability of prey is the same for the partly diurnal birds of the Selvagens and for their nocturnal conspecifics of the Canary Islands, which prospect the same waters of the Canary Current (Mougin & Jouanin 1997). Two species have been reported to prey upon Cory's Shearwaters-humans and the Yellow-legged Gull *Larus cachinnans*[3]. However, the Yellow-legged Gull is not a predator of Cory's Shearwaters on Selvagem Grande, even less of adults than of eggs and chicks; the large body size of the shearwater protects it from the gull. Past predation by humans on Cory's Shearwaters was mostly on chicks and occurred at the end of September and beginning of October during the morning hours when adults were not present in the colonies (Schmitz 1893); similar exploitation occurred in the Canary Islands (Lovegrove 1971; Martin *et al.* 1991). It is unlikely that a nocturnal species would become diurnal to avoid diurnal predators. Thus, the various hypotheses do not accord well with our observations. We propose as an alternative hypothesis that the observed diurnal behaviour is a consequence of very high breeding numbers.

Today, the size of the breeding population of Selvagem Grande, about 36 000 birds (Mougin *et al.* 1996), is very much reduced following exploitation and poaching. At one time, the population numbered about 300 000 birds, 250 000 of which probably landed to prospect or breed. All of these would congregate on an area of about 2 km². It seems unlikely that so many birds could have displayed in flight in close proximity and in the dark without collisions, and in the absence of conditions conductive to good transmission of the information conveyed by their songs. Population pressure may thus have resulted in a switch to diurnal activity, rendered possible by the lack of predators. Such a shift to diurnal behaviour has been observed in superabundant populations of another large shearwater, the Sooty Shearwater *Puffinus griseus* in New Zealand (Serventy *et al.* 1971), but not in abundant populations of smaller shearwaters liable to predation such as the Manx Shearwater *Puffinus puffinus*, for example (Brooke 1990).

Clearly, the almost complete absence of predators could have permitted partly diurnal habits in many other localities, but populations of Cory's Shearwater may never have been large enough to effect a shift – 45 000-50 000 breeding pairs when numbers were at their peak on the 10.5 km² of Alegranza, Canary Islands (Martin *et al.* 1991; Martin & Nogales 1993) and 20 000-25 000 pairs on the 3.4 km² of Zembra (Gaultier 1981), both localities being known to host the most abundant populations of Cory's Shearwater after Selvagem Grande.

Cory's Shearwater on Selvagem grande Kuhls Pijlstormvogel op Selvagem grande (J.-L. Mougin)

The decline in numbers during the last few decades has not resulted in a reversion to strictly nocturnal behaviour in the birds of Selvagem Grande. In fact, the partly diurnal behaviour they exhibit is by no means disadvantageous and there has been no pressure for change. Besides, the population decline has been very sharp and is a relatively recent phenomenon.

The relationship between bird numbers and time of first returns observed on Selvagem Grande might have been expected; the larger the sample size then the wider the range and the earlier the first record - the birds perhaps acquiring information on the number of conspecifics expected to be in the colonies that night in the rafts where they settle during the afternoon, sometimes for hours, before returning to their colonies. However simple and obvious such a relationship may be, it has not been observed in the other breeding localities insofar as one can judge by the data published (Bannerman 1914; Mallett & Coghlan 1964; Fernandez 1979; Vaughan 1980; Servent 1987); the first returns usually occur at fairly constant times except during moonlit nights (Klomp & Furness 1992). This being so, either the numbers are constant day after day,

which would imply the absence of the attendance cycles observed on Selvagem Grande, or attendance cycles exist but have no influence on the hours of first returns. Data on the overall numbers of Cory's Shearwaters present nightly would resolve the problem but are at present lacking.

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HET TIJDSTIP VAN AAN LAND KOMEN DOOR KUHLS PIJLSTORMVOGELS *CALONECTRIS [DIOMEDEA] BOREALIS*[1] OP SELVAGEM GRANDE IN DE BROEDTIJD

Het tijdstip van het aan land komen door Kuhls Pijlstormvogels Calonectris [diomedea] borealis[1] *op Selvagem Grande (30°09'N, 15°52'W) blijkt negatief gecorreleerd te zijn met het aantal vogels dat per avond naar de kolonie terugkeert. De gemiddelde aankomsttijd vertoonde van mei tot september echter geen significante verschillen. In tegenstelling tot hun verwanten in andere Atlantische kolonies en in kolonies in de Middellandse Zee komen de Kuhls Pijlstormvogels van Selvagem Grande niet alleen 's nachts aan land. Dit gedrag kan nog stammen uit de tijd dat de kolonies op Selvagem Grande enorm groot waren, voordat de overexploitatie in de jaren zestig en zeventig haar tol had geëist. Populatiedruk kan hebben geleid tot dagactiviteit, hetgeen mogelijk was door een gebrek aan predatoren gedurende de dag.*

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Footnotes

[1] *Calonectris diomedea borealis* is presently known as *Calonectris borealis* on the Dutch List (Ardea 87: 139-165).
[2] *Calonectris diomedea* was used as either the Mediterranean or the Atlantic race of Cory's Shearwater. On the Dutch list, these types are considered specifically distinct on the basis of phylogeographic analysis of allozymes and mitochondrial DNA, vocalisations and morphology (*Ardea* 87: 139-165) and the text should therefore read *Calonectris* sp.
[3] *Larus cachinnans* is presently known as *Larus michahellis* on the Dutch List (*Ardea* 87: 139-165).