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Breeding ecology of the Kentish Plover, Charadrius alexandrinus, in the Farasan Islands, Saudi Arabia

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Breeding ecology of the Kentish Plover, *Charadrius alexandrinus*, in the Farasan Islands, Saudi Arabia

(Aves: Charadriiformes)

Monif AlRashidi, András Kosztolányi, Mohammed Shobrak, Tamás Székely

Abstract. The breeding behaviour and ecology of the Kentish Plover, *Charadrius alexandrinus* Linnaeus, were investigated in three consecutive years in the Farasan Islands, Saudi Arabia, where the species breeds either under halophytic bushes or in exposed sites where ground temperatures may reach 60°C. Three aspects make the Farasan Island population distinct from most other Kentish Plover populations studied to date. First, incubating plovers appear to prefer nesting under halophytic bushes rather than in exposed sites, since 65.1% of nests were under bushes, whereas 34.9% of nests were in fully exposed sites. Second, both mate fidelity and nest-site fidelity were high, and pairs stayed within short distances from their previous nest sites. Third, brood desertion was very rare in the Farasan Islands – unlike most other populations where the female or the male deserts the brood shortly after hatching of the eggs – since in 95% of broods both parents attended the chick(s) (n = 153 broods). We suggest that these social traits are driven by the extreme hot environment that requires parental cooperation, although adaptation to island-dwelling and corresponding changes in life-history traits cannot be ruled out.

Key words. Parental cooperation, brood desertion, mate fidelity, nest-site fidelity.

Introduction

The Kentish Plover, *Charadrius alexandrinus* Linnaeus, is a small ground-nesting shorebird (body mass is about 42 g) which has a distinct diverse breeding system among birds (SZÉKELY et al. 2006). Both parents incubate the eggs, although after the eggs hatch one parent (usually the female) may desert the family and seek a new mate. Therefore, variation in both mating system (monogamy, polygyny and polyandry) and brood care (biparental, male-only and female-only) may all occur within a single population (LESSELLS 1984, SZÉKELY & CUTHILL 1999, KOSZTALÁNYI & SZÉKELY 2002, SZÉKELY et al. 2006, AMAT et al. 2008). In addition, breeding systems tend to vary between populations and this may be caused genetically (e.g. gene frequencies are different between populations) and/or in response to the local environment where the plovers breed. Recent studies have conjectured that several environmental factors can influence the distribution of care types in Kentish Plovers. It has been suggested that biparental care is associated with hot ambient temperatures, competition between plover families and a high predation risk on chicks (SZÉKELY & CUTHILL 1999, SZÉKELY et al. 1999, KOSZTOLÁNYI et al. 2006, AMAT et al. 2008, ALRASHIDI et al. 2010). Understanding the causes of this variation in breeding systems both across and within Kentish Plover populations is necessary to predict how breeding systems (*sensu* KOSZTOLÁNYI et al. 2006) may respond to environmental changes.

Kentish Plovers usually nest in open habitats, although in some populations they also uti-

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lise cover so that the nests are under a small shrub (FRAGA & AMAT 1996, AMAT & MASERO 2004a).This diversity in nest location may be associated with parental condition and/or environment (high ambient temperature and/or predation risk) (AMAT & MASERO 2004a, b).This diversity may lead to variations in parental behaviour and care, egg patterns of development and adult survival. The aims of our study were: 1) to collect baseline data on the behaviour and breeding ecology of the Kentish Plover in the Farasan Islands. The only detailed study of this species from the Middle East was carried out on the mainland in the United Arab Emirates (KOSZTOLÁNYI et al. 2009), 2) We conjectured that the extreme hot environment, and/or life-history adaptations to island breeding may influence breeding success, distribution of care types, and mate and nest-site fidelity. We investigated this conjecture by comparing the behaviour of Farasan Island plovers with that of other plover populations.

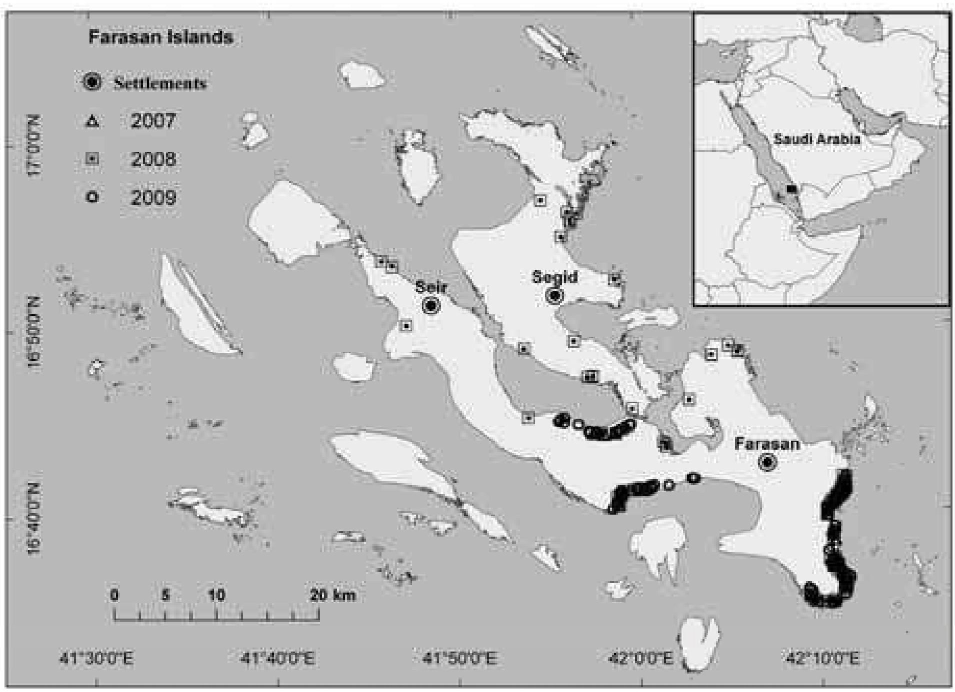

Fig. 1. Map of the Farasan Islands showing the locations of Kentish Plover nests.

Study area

Fieldwork was carried out between 8 and 19 July 2007, 17 April and 4 July 2008, and 15 May and 4 July 2009.We collected data in each year on the largest island of the Farasan Islands, Farasan (369 km^2), and in 2008 we extended fieldwork to the second largest island, Sagid (109 km^2, Fig. 1). These two islands are inhabited by a total population of about 4500 people. The Farasan Islands are an archipelago that is located in the Red Sea about 50 km from the city of Jizan, Saudi Arabia. The archipelago is a protected area established in 1996 by the Saudi Wildlife Commission (SWC), and covers an area of 3,310 km^2. It is recognised as an Important Bird Area by

BirdLife International (PERSGA/GEF 2003). The Farasan Islands have a subtropical desert climate, with sparse rainfall and average annual precipitation of less than 50 mm, but being surrounded by the sea, they are humid all year round (NCWCD 2000). These islands comprise a variety of habitat types including mangrove (*Avicina marina*), wet and dry salt marshes, sand dunes, sand plains and rocky habitats (El-Demerdash 1996). Vegetation is dominated by halophytic plants such as *Halopeplis perfoliata, Zygophyllum album, Z. coccineum, Z. simplex, Limonium axillare,* and *Suaeda monoica*. The degree of grazing pressure by wild Farasan Island Gazelles (*Gazella gazella farasani* Thoulless & Al Basari) and domestic herds (e.g. goats and camels) is low, and so these plant species are abundant, covering a huge area of salt marsh and sand dunes and providing nesting sites for shorebirds (NCWCD 2000).

Methods

Kentish Plovers breed sparsely up to 1 km away from the shore, either under bushes or in open areas. Searching for nests was time-consuming, because the area suitable for nesting was huge, and there were many bushes which made it difficult to spot incubating adults. Two methods were used to locate nests: 1) by driving a car and flushing the incubating birds. Some plovers continued incubating until the car was only few metres from them. Consequently, to avoid damaging the nest, the car was driven slowly and frequently stopped, and a walk was made about 100 m around the car to spot flushed plovers. 2) By watching incubating birds when they visited the sea to soak their bellies, a behaviour that occurs in particular between 10.00 and 15.00 (local time, GMT + 3 hours), and following these parents back to their nests. Once a nest was found, it was photographed and its location was recorded using a hand held GPS unit. Nests were allocated to five cover categories: completely exposed nests that had no cover (0), <25% cover (1), 26-50% cover (2), 51-75% cover (3) and >75% cover (4).Temperature was measured near certain nests by a thermo-probe which was placed about 25 cm from the nest scrape in an open area at ground level. The probe was connected to a data logger (Tinytag, Gemini Data Loggers Ltd.) that recorded the temperature every 20s for more than 24 hours. The maximum ground temperature recorded was 60.3°C, and ground temperature often exceeded 50°C at midday. The sea was the only water source and the distance from the sea was measured as the perpendicular distance to the nearest coast. Distance from the sea was divided into 9 categories of 100 m each.

Clutch size was also recorded. Egg floatation was used to estimate the date of egg laying (see Székely et al. 2008). Most nests were visited every 2-5 days. The fate of the clutch was assigned to one of the following categories: (1) Hatched when at least one egg hatched, (2) Predated when the eggs were eaten, (3) Failed when no eggs hatched but the reason for failure was not predation, (4) Abandoned when no adults were observed at the nest, or there were no plover footprints around the nest, or (5) Unknown when the fate of the nest was not followed or the eggs disappeared although neither predation nor hatching was confirmed.

We used Generalized Linear Models (GLMs) with binomial error to test whether nest fate (hatched or predated) differs between nest cover categories. Distance from the sea, egg laying date and years may all affect nest fate, so we included these variables in the initial models.

Parents were captured by funnel traps on the nest, or with downy chicks. The chicks were covered by a sieve large enough to accommodate all the young, and the funnel trap was put around the sieve. Adult plovers were ringed with metal rings provided by SWC, Saudi Arabia, and 1-3 coloured rings. Chicks were ringed with only two rings, a metal ring and a coloured one. Body mass was measured with a Pesola spring balance, the right tarsus length with sliding callipers, and the right wing length (only for adults) with a wing ruler. We did not attempt to follow colour-ringed families, although when a brood was encountered, the sex, the number of attending parents and the number of chicks were recorded. Some chicks were also recaptured and their weight and right tarsus length were recorded again. Adult males and females were usually straightforward to distinguish. For further methods. see SZÉKELY et al. (2008).

Statistical analyses were carried out using R 2.10.0 (R Development Core Team 2010) and SPSS 17.0. For non-parametric data we provide the median (M), the lower quartiles (LQ) and the upper quartiles (UQ).

Table 1. The fate of Kentish plover nests in the Farasan Islands.

Year	Hatched	Predated	Failed	Abandoned	Trampled	Unknown	Total
2007	3	1				2	6
2008	15	94	2	2		49	162
2009	14	63		1	1	25	104

Results

Egg-laying dates and nest locations

In total 272 nests were found: six nests in 2007, 162 nests in 2008 and 104 nests in 2009. Most eggs were laid in May and June, although we already encountered chicks in April in 2008. Therefore, based on the estimated ages of chicks and egg-lying date, the breeding season may start as early as February, and it may last until late August.

Kentish Plovers breed in areas with no or little mangrove, and most nests (n=162 nests) were found in the eastern part of the main island where there were no mangrove trees (Fig. 1). 177 nests were under halophytic bushes, whereas 95 nests were in fully exposed sites. Bushes may serve as a shelter from the direct solar radiation, since about 35.7% of nests had very good to excellent shade (categories 3-4), whilst 9.9% of nests had a little shade, covering less than 25 % (category 1, Fig. 2). Nest distance from the sea ranged from 5 m to 850 m. The number of nests decreased exponentially with the distance from the sea (Exponential regression: $r^2 = 0.98$, $F_{1,7} = 303.28$, $P \leq 0.001$, n=272 nests, Fig. 3).

Out of 190 completed nests 100 had three eggs, 79 had two eggs and 11 had only one egg. Clutch sizes did not differ between the nest cover categories (Kruskal–Wallis test, $\chi^2 = 2.23$, df = 4, P=0.693).

The fate was known for 196 nests (Table 1). Predation was high since 80.1% of the nests were predated (n=157 nests), whereas only 14.8% of clutches produced chicks (n=29 nests). Nest failure decreased as the breeding season progressed (GLM with binomial error, B = -0.03±0.01, P=0.007). Nest-cover, year, distance from the sea and the interaction between nest-cover and distance from the sea did not influence nest fate (P>0.05), and therefore none of these variables was included in the final model.

Most nests (n=105) were predated by terrestrial predators (stray domestic cats, *Felis domesticus* Erxleben, or White-tailed Mongoose, *Ichneumia albicauda* Cuvier) whose footprints were found around predated nests. Domestic cats were observed near some nests, and nest cameras identified a mongoose. Three nests were predated by a large bird, possibly the

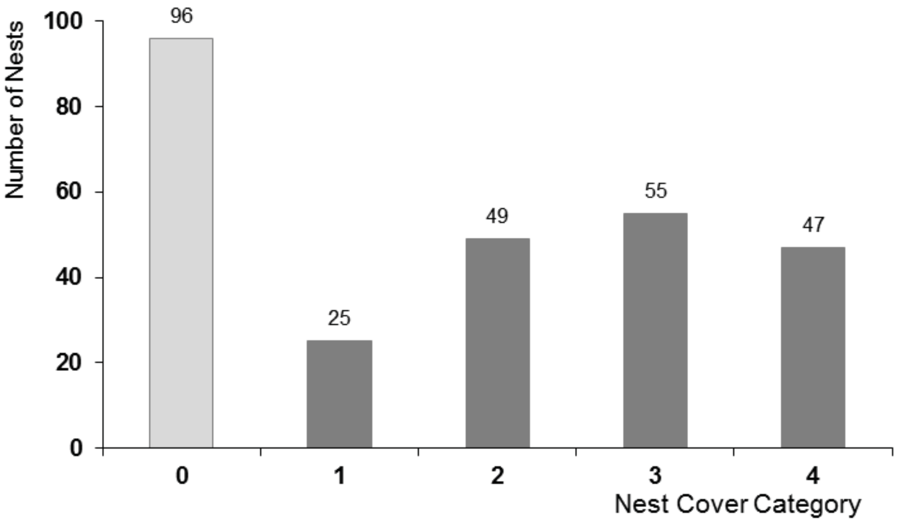

Fig. 2. Cumulated frequencies of nest numbers for a given nest cover category. Nests were allocated to five cover categories: completely exposed nests that had no cover (0), <25% cover (1), 26-50% cover (2), 51-75% cover (3) and >75% cover (4). N=272 nests for 2007-2009.

Indian House Crow (*Corvus splendens* Vieillot), and its footprints were found around predated nests. At many nests, however, the predators did not leave footprints so that their identification is unknown. The Hoopoe Lark (*Alaemon alaudipes* Desfontaines) destroyed five nests by opening the eggs and throwing them out of the nests. The Hoopoe Larks attacked the eggs when the parents were absent (early morning and late afternoon).

Brood-rearing

Kentish Plovers have biparental brood care in the Farasan Islands. We trapped 514 Kentish Plovers (239 adults and 275 chicks) in 153 families (22 families in 2007, 53 families in 2008 and 78 families in 2009). In all families, both parents were observed (or captured) with their chicks except in eight families where either the female or the male was absent (n = 5 and 3 families, respectively). We spent 30-60 min with each family and the absent parent could be with the rest of the chicks or incubating un-hatched eggs. If only one chick was captured, one parent stayed around the trap whereas the other led the other chicks away. In some nests that were far away from the sea, when one egg hatched one parent took the chick to the sea whereas the other parent continued incubating the eggs. The chick age of all families ranged from one day at hatching to about 40 days when chicks could fly. In three families which were re-sighted until the chicks were 40 days old, both parents stayed with their chicks. In another ten families, the chicks were recaptured within 10-20 days from the first capture and both parents attended these chicks.

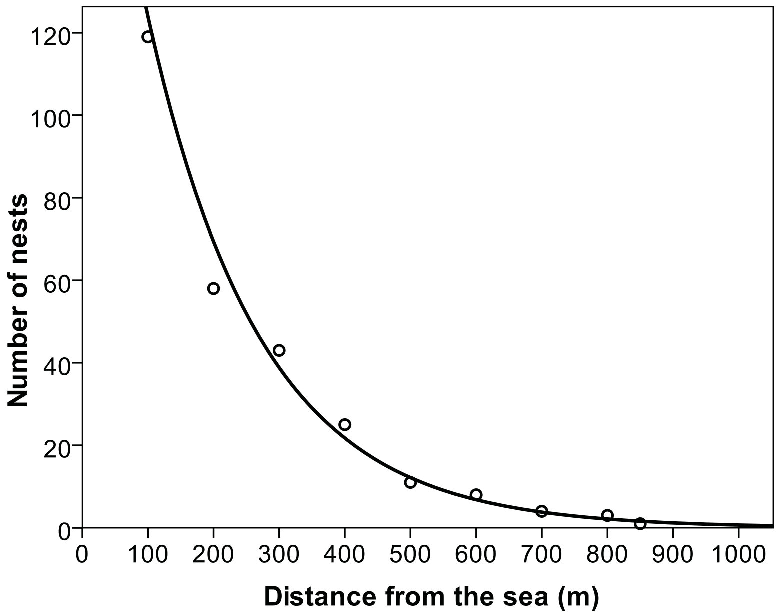

Fig. 3. The number of Kentish Plover nests in relation to distance from the sea.

Mate fidelity and site fidelity

Kentish Plovers kept their mates for several breeding attempts. In 63 pairs in 2008, both parents were ringed, and in 24 of these pairs both parents were recaptured in 2009. In 19 pairs out of 24, the pairs stayed together whereas in 5 pairs they divorced. Two of the 19 pairs re-nested in the same nest scrape, and these two pairs were out of only 15 pairs that nested successfully in 2008, whereas the other pairs moved to new sites 105 m away (median) (70-157.5 m, (LQ–UQ), n = 17 pairs). Five pairs of those which nested in covered sites re-nested with almost the same cover type, whereas four pairs moved from exposed sites to covered ones. Two of these four pairs experienced nest failure in 2008, and one nest was manipulated by covering it with excellent cover in 2008, which may have led them to change their nest covers (Spearman rank correlation coefficient between 2008 nest-cover and 2009 nest-cover, r_s=0.124, N=9, P=0.751).

Three males and two females that changed their mates between 2008 and 2009 moved to new sites; one female moved 600 m from its previous nest scrape, and the other 155 m, whereas the males moved 145 and 65-60 m (n = 3 males).

In 2008, three pairs that lost clutches at the beginning of the breeding season re-nested together late in the season in another scrape with the same nest cover type. In 2009 one of 11 pairs that were ringed in 2007 re-mated with the same partner, and their nest was 215 m from their previous nest; although we have no information about this pair from 2008.

Discussion

Firstly, in spite of being an island population, clutch predation was high. Nest failure was primarily attributed to the introduction of mammalian predators, mainly White-tailed Mongoose and stray cats. In the Farasan Islands, White-tailed Mongoose causes nest failure not only for Kentish Plover but also for the other ground-nesting birds including the Osprey (*Pandion haliaetus* Linnaeus) (NCWCD 2000, PERSGA/GEF 2003). We argue that although the Mongoose may be a natural mammalian predator in the Farasan Islands, it may achieve unnaturally high densities due to the availability of food, particularly domestic garbage. We suggest that to enhance the nest success of birds, the numbers of Mongoose should be controlled. Alternatively, some islands should be made predator-free by eradicating mongoose and cats.

Secondly, plovers seem to prefer nesting under bushes rather than in exposed sites. This behaviour appears to be different from the Kentish Plovers in Spain as reported by AMAT & MASERO (2004a). Despite the abundance of *Arthrocnemum* at Fuente de Piedra, the main plant used for nest cover, they found most Kentish Plover nests in sites with little or no cover. We suggest two explanations for this difference. First, midday temperatures may be higher in the Farasan Islands than in Fuente de Piedra, which may select for nesting under bushes. Second, many shorebirds nest in exposed or semi-exposed sites to minimize predation risk, on both nest contents and incubating adults alike, because such sites facilitate the early detection of predators (GRANT 1982, BURGER 1987, WARD 1990, AMAT & MASERO 2004a). Although clutch predation was almost similar and nest fate did not differ between covered nests and exposed ones either at Fuente de Piedra Lake or in the Farasan Islands, predation on incubating plovers at Fuente de Piedra Lake appears to be higher than in the Farasan Islands. AMAT & MASERO (2004a) reported that some adults were predated on/near their nests and most of these were at covered sites, whereas we did not observe any signs indicating that incubating plovers were predated on/near their nests. Since eggs in covered nests and exposed nests were predated at a similar rate in the Farasan Islands and there was no risk to incubating plovers at both types of nest, Kentish Plovers which experienced clutch predation in exposed sites may move to nest under bushes because there was no advantage in nesting in exposed sites (see results, nest site fidelity).

Thirdly, brood desertion in the Farasan Islands is rare and thus biparental care was more common in this population than in other populations studied to date (LESSELLS 1984, SZÉKELY & LESSELLS 1993). Moreover, both parents appeared to stay with their chicks longer than those in the other populations (FRAGA & AMAT 1996, KOSZTOLÁNYI et al. 2009). We suggest three explanations why brood desertion is rare in this population. First, mate availability may be low in the Farasan Islands and thus the deserting parent may have no chance of remating and raising another brood. Given that mate availability depends on adult sex ratio and brood care patterns, it is important to estimate the adult sex ratio in the future. Second, hot temperatures especially at midday may favour shared brood care as both parents are needed to brood and shade the chicks to avoid overheating (KOSZTOLÁNYI et al. 2009). However, this may not be a probable explanation in the Farasan Islands, because chicks may cool themselves by bathing in the sea or by moving under the abundant bushes. Also, in another hot environment, Abu Dhabi, KOSZTOLÁNYI et al. (2009) reported frequent brood desertion. Third, competition between plover families, food distribution and high predation on the chicks may favour biparental care with high parental cooperation (FRAGA & AMAT 1996, KOSZTOLÁNYI et al. 2006, KOSZTOLÁNYI et al. 2007). We observed fights between neighbouring families and some chicks were injured. This occurs usually when the tide rises and the foraging area shrinks, and the plovers and other shorebirds thus concentrate in a small strip of shore-line. Infanticide by adults has been reported in several populations (FRAGA & AMAT 1996, SZÉKELY & CUTHILL 1999). KOSZTOLÁNYI et al. (2006) found that when food distribution was patchy, the density of plovers and competition between plover families increased and parents spent more time defending their chicks.

Finally, although nest predation was high and the breeding season was almost continuous and lasted for a long period (up to 7 months), we found high mate fidelity and nest-site fidelity. Breeding failure may induce low nest-site and mate fidelity (WARRINER et al. 1986, HAIG & ORING 1988, THIBAULT 1994, FLYNN et al. 1999). The length of the breeding season and the operational sex-ratio may also influence both nest-site and mate fidelity (LLAMBÍAS et al. 2008, LLOYD 2008). Our result is partially consistent with the study of KOSZTOLÁNYI et al (2009) who found high nest-site fidelity but low mate fidelity in Abu Dhabi. A possible explanation for the difference between these studies in mate fidelity may relate to a difference in the mate availability between the two populations or because island-breeders may exhibit different behaviours from mainland ones. KOSZTOLÁNYI et al (2009) found two cases of divorce between nest attempts within a season, whereas we did not observe any cases.

Taken together, the Farasan Islands provide some of the most important breeding areas for Kentish Plovers in Saudi Arabia. The breeding biology of the Kentish Plover in the Farasan Islands appears to be different from other populations. We hypothesise that these differences are largely due to the high ambient temperature although we cannot exclude alternative explanations. The Farasan Island conservation authorities need to control the numbers of domestic cats and mongoose. This urgent management issue needs a quick resolution; and we strongly advise fencing some areas on the two largest islands to protect the Kentish Plover from these predators. These areas should be large enough (at least 1 km^2) to provide safe and adequate nesting sites and brood-rearing sites.

The Kentish Plover population in the Farasan Islands offers an excellent opportunity to investigate the life-histories of these individuals and it is ideal for long-term monitoring and carrying out specific ecological research. Future research studies should focus on the following topics: (1) investigate the movements and site fidelity of Kentish Plovers over a longer time-scale to verify our present findings; (2) estimate the survival of adults and juvenile Kentish Plovers and model population sex ratio; (3) collect more data on brood care in order to compare the behaviour of Farasan Island Kentish Plovers with those on mainland Saudi Arabia; and (4) carry out a long-term study for nest-cover preference of individual parents and their chicks.

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