Seasonal pattern of plumage colour in Yellow-legged Gulls at Bay of Biscay, Spain

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Large birds often pass through different plumage phases until they reach the mature, adult-like plumage. The identification of such plumages is crucial, because it allows us to determine the age correctly (Svensson 1992, Baker 1993, Jenni & Winkler 1994, Martínez et al 2002), and this is fundamental when we want to model how a parameter (eg, survival, dispersal distance, diet, etc) varies according to the bird's age (eg, Hake et al 2003, Oro et al 2013, Cresswell 2014). Plumage details also play an important role for the identification of many species, such as most gulls (eg, Olsen & Larsson 2004).

Yellow-legged Gull *Larus michahellis* is one of the most abundant large white-headed gulls in south-western Europe (mainly Iberia, southern Mediterranean France and the western Mediterranean islands), north-western Africa and the Macaronesian region (Olsen & Larsson 2004). Two decades ago, the species colonized the English Channel and some other areas in central western Europe (Yésou 1991, Neubauer et al 2010).

Two subspecies are recognized. Nominate *L m michahellis* occurs in southern and western Black Sea coasts, Mediterranean, Iberia, western France, and is partially migratory; it winters in part in the Bay of Biscay. *L m atlantis*, of which the distribution range is under revision, is a resident, considered to occur from the Azores to all of Macaronesia or an even wider area including north-western Africa. A third population, breeding along the Atlantic region of Iberia, probably up to south-western Iberia (but with its distribution range also under revision), is also sedentary and has sometimes been recognized as a third subspecies '*L m lusitanius*' (eg, Olsen & Larsson 2004) but is normally included in *L m michahellis* (Dickinson & Remsen Jr 2013, Gill & Donsker 2019). These two (or three) subspecies show differences in body size, structure and plumage colour pattern (Mínguez & Ganuza 1995, Bosch 1996, Olsen & Larsson 2004, Arizaga et al 2008, Aguirre et al 2009), voice (Teyssèdre 1984), timing of breeding (Arizaga et al 2012, Baaloudj et al 2014) and migratory behaviour (Munilla 1997, Arizaga et al 2010, Galarza et al 2012).

As other related species, Yellow-legged Gull shows four age-groups, reaching adult-like plumage when aged four, after a complete moult in the fourth year of life (Olsen & Larsson 2004). Until then, immatures go through different plumage phases where the brown, juvenile coloration is progressively replaced by a higher amount of grey feathers in the wings, mantle and scapulars and white on the head, underparts and tail (Olsen & Larsson 2004).

Yellow-legged Gull undergoes an annual complete moult before the winter, except in first-year birds, which conduct a partial moult involving head, body and some wing-coverts (and a variable number of lesser, median and inner greater coverts, with high variation between individuals and populations). The post-juvenile moult lasts from July to even February (Jonsson 1998, Schweizer 2003), usually up to October (Olsen & Larsson 2004). Whiter coloration of birds in their first year of life in the head and underparts is due to wear/bleaching. The replacement of body feathers or wing-coverts in late winter or spring can be regarded as a small partial moult before summer or as first steps of a complete moult (Howell & Dunn 2007). Complete moults last from April to November, although the start and end dates again vary rather substantially between individuals and populations (Olsen & Larsson 2004). For the particular case of the '*lusitanius*' Yellow-legged Gull population(s), the moult and transition between different plumage types have never been described in detail, as far as we know.

The aim of this paper is to describe in detail the seasonal sequence of the different plumages acquired by a resident '*lusitanius*' Yellow-legged Gull population at the Bay of Biscay in northern Spain.

Material and methods

Study area and data collection

Yellow-legged Gull chicks were ringed in four

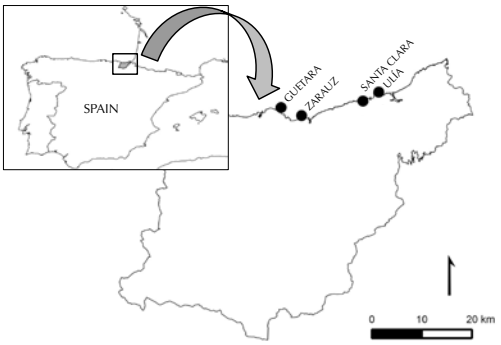

FIGURE 1 Location of sampling colonies of Yellow-legged Gull *Larus michahellis* in Gipuzkoa, Spain

TABLE 2 Number of Yellow-legged Gull *Larus michahellis* chicks ringed in four colonies in Gipuzkoa, Spain, in 2005-15

Year	Ulia	Santa Clara	Zarauz	Guetaria
2005	17	23	13	0
2006	148	69	0	30
2007	212	85	12	10
2008	228	55	8	38
2009	289	50	0	20
2010	232	42	0	59
2011	200	37	0	32
2012	178	87	0	65
2013	68	54	0	50
2014	151	59	0	51
2015	147	35	0	50
Total	**1870**	**596**	**33**	**405**

colonies in Gipuzkoa, northern Spain (figure 1). Ringing was carried out in late June, from 2005 to 2015. The number of chicks ringed per year ranged from 53 in 2005 to 359 in 2009. Overall, 2904 chicks were ringed (table 2). The chicks were ringed with both a metallic and a PVC colour-ring with an alphanumeric code, the latter allowing us to identify the bird at distance.

Once these individuals leave the colonies, they are seen everywhere along the coast or inland, in harbours, along rivers, at intertidal flats and dumps, mostly within a radius of 50 km from their natal colonies (Arizaga et al 2010). Our dataset consists of sightings of these ringed gulls, reported by birders or by us, compiled from 2006 to May 2016. Plumage was analysed by the authors, both in the field and, more frequently, based on photographs. For each bird, we annotated the date and the type of plumage, using the guide-code described in table 1. Examples of the plumages can be seen in figure 2. The decision to use this code was due to the relative subjectivity to assign the 'classic' first-, second- or third-winter or summer plumages normally considered in identification guides (eg, Olsen & Larsson 2004). We were especially interested in quantifying the amount (percentage) of grey in the dorsal and wing feathers, a variable that we wanted to record independently of the exact age of the bird. We also used this code since we found that in some ringed birds of known age, a mismatch occurred between known age and the age based on plumage characters (if

TABLE 1 Criteria used to determine different plumage types in Yellow-legged Gull *Larus michahellis*

Plumage description	Plumage type (as used in this paper)	Equivalent (Olsen & Larsson 2004)
Juvenile	1	juvenile
At least one first-winter feather in mantle and/or scapulars	2	first-winter/first-summer
Mantle/scapulars with <50% of adult-like grey feathers; no grey feathers in wing-coverts	3	first-summer/second-winter
Mantle/scapulars with <50% of adult-like grey feathers; some grey feathers in wing-coverts	4	second-winter
Mantle/scapulars with ≥50% of adult-like grey feathers; <50% grey feathers in wing-coverts	5	second-winter/second-summer
Mantle/scapulars grey; >50% grey feathers in wing-coverts	6	third-winter
Adult-like plumage, besides some immature feathers in wing-coverts and/or tail	7	third-winter/third-summer
Adult breeding and non-breeding; wing-coverts grey; all body- and tail-feathers white; bill and legs yellow; in non-breeding period, head with some brownish feathers	8	adult

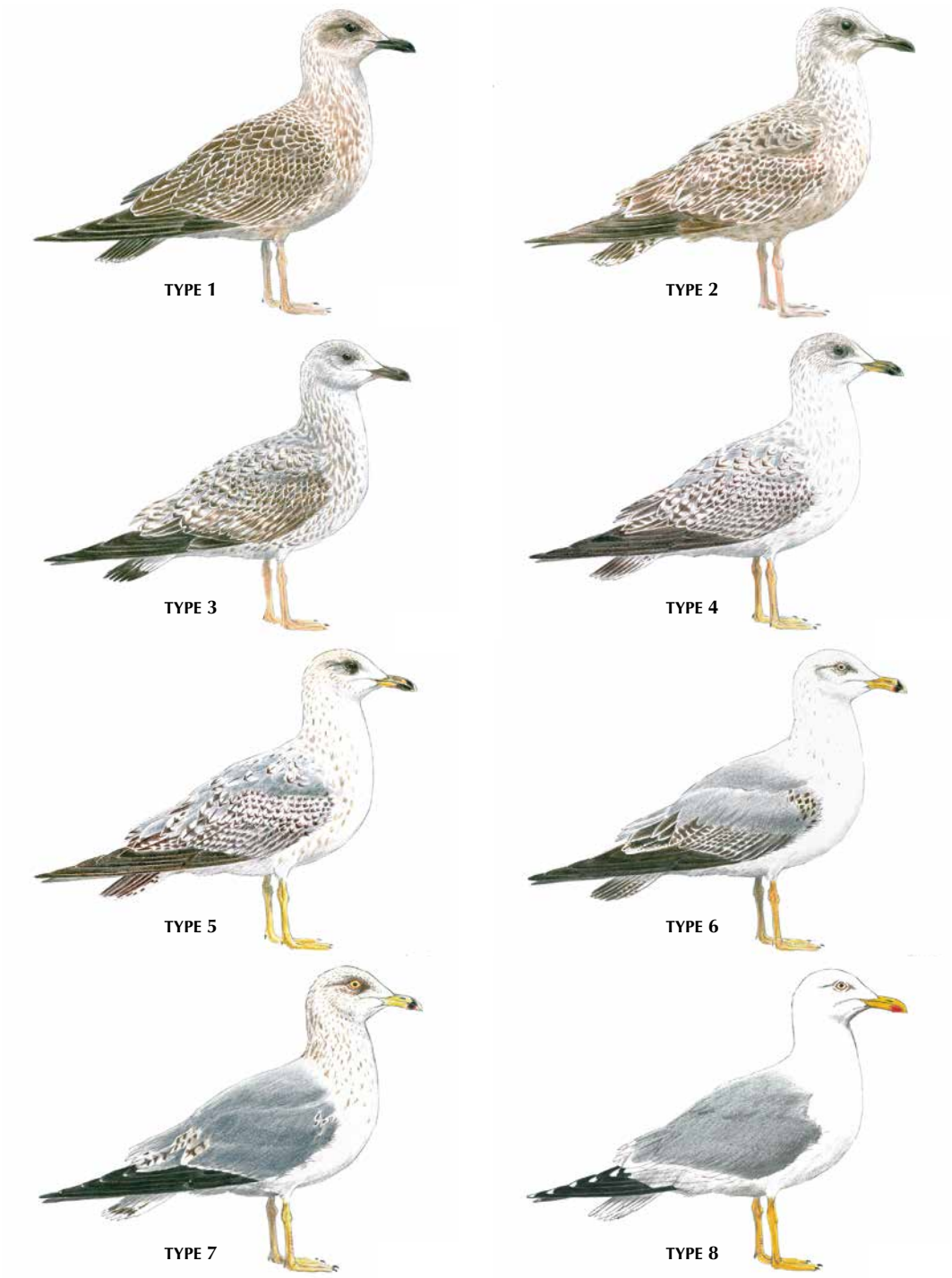

FIGURE 2 Plumage types of Yellow-legged Gull *Larus michahellis* identified in this paper *(Gorka Gorospe)*

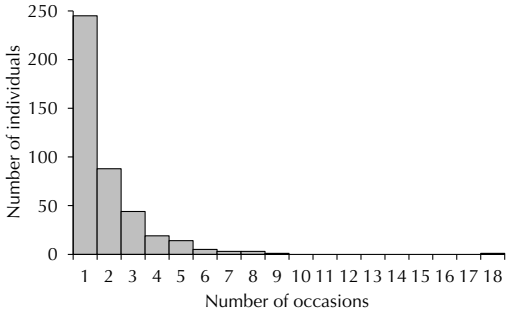

FIGURE 3 Frequency distribution of number of occasions (months) in which each individual of Yellow-legged Gull *Larus michahellis* was used for analyses

using the 'classic' criteria). Each bird was then also assigned to an approximate age, with July of the hatching year being the first time unit (month) in the study. In most cases, birds were aged when they were on the ground and, less frequently, in flight. This entails that primary coverts often remained unseen resulting in some gulls with signs of immaturity in these feathers being classified as category 8 (when they were actually category 7; table 1). We may thus have underestimated the proportion of birds in category 7.

Data analyses

Each individual was considered only once per time unit (month) in order to remove pseudo-replications. To test for the sequential replacement of the different plumage types, we used a Generalized Linear Mixed Model with the type of plumage as an object variable, date (month) as a factor, and individual as a random factor. We used a linear-link function with Gaussian errors distribution. Statistical analyses were conducted with R (R Development Core Team 2014).

Results

Overall, 725 records relating to 416 individuals were analysed. The number of analysed months in which plumage of individuals was classified varied between one (c 61.0% of all individuals) to 16 (one individual; 0.5%) (figure 3). Sample sizes of plumage categories differed between 8 (type 4) and 156 (type 8), with a mean of 68 individuals.

Once controlled for the (potential) effect of each individual bird, plumage types succeeded sequentially practically without statistical overlap between them (F=324.28, P<0.001; figure 4). The juvenile plumage was only present during a period of c four months from fledging, until October

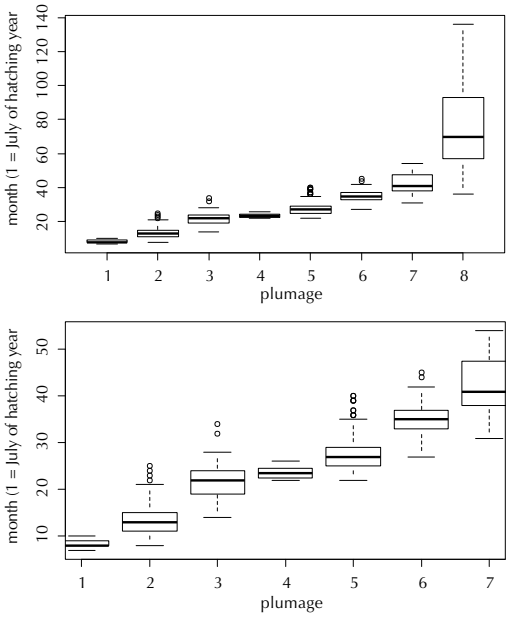

FIGURE 4 Seasonal replacement (boxes: IQR; whiskers: minimum and maximum values; dots: outliers) of distinct plumage patterns (type 1-8 from table 1; type 1 corresponds with juvenile plumage, type 8 with adult plumage) observed in a Yellow-legged Gull *Larus michahellis* population at Bay of Biscay, northern Spain. The sampling period was cut in month 136; months 61-136 correspond to category 8. Below: same boxplot with category 8 removed. According to our model, the beta-parameters estimates (±SE; referenced to type 1 plumage; beta=0) were: type 2 = +3.92 ± 2.10 (P<0.001); type 3 = +12.80 ± 2.52 (P<0.001); type 4 = +14.78 ± 4.23 (P<0.001); type 5 = +19.45 ± 2.42 (P<0.001); type 6 = +30.12 ± 2.74 (P<0.001); type 7 = +36.08 ± 2.74 (P<0.001); and type 8 = +63.56 ± 2.28 (P<0.001).

of the first calendar-year. Type 2 plumage, however, was present for a period of 18 months, up to January of the third calendar-year. Type 3 plumage was present also during a long period (21 months), from February of the second calendar-year to October of the third calendar-year. In contrast, type 4 plumage was present for only a very short time period, constrained to five months during the last part of the second calendar-year up to February of the third calendar-year. Type 5 and 6 plumages appeared during a period of 19 months: type 5 from October of the second calendar-year up to April of the fourth calendar-year and type 6 from March of the third calendar-year up to September of the fourth calendar-year. Type 7 plumage was present during a period of 24

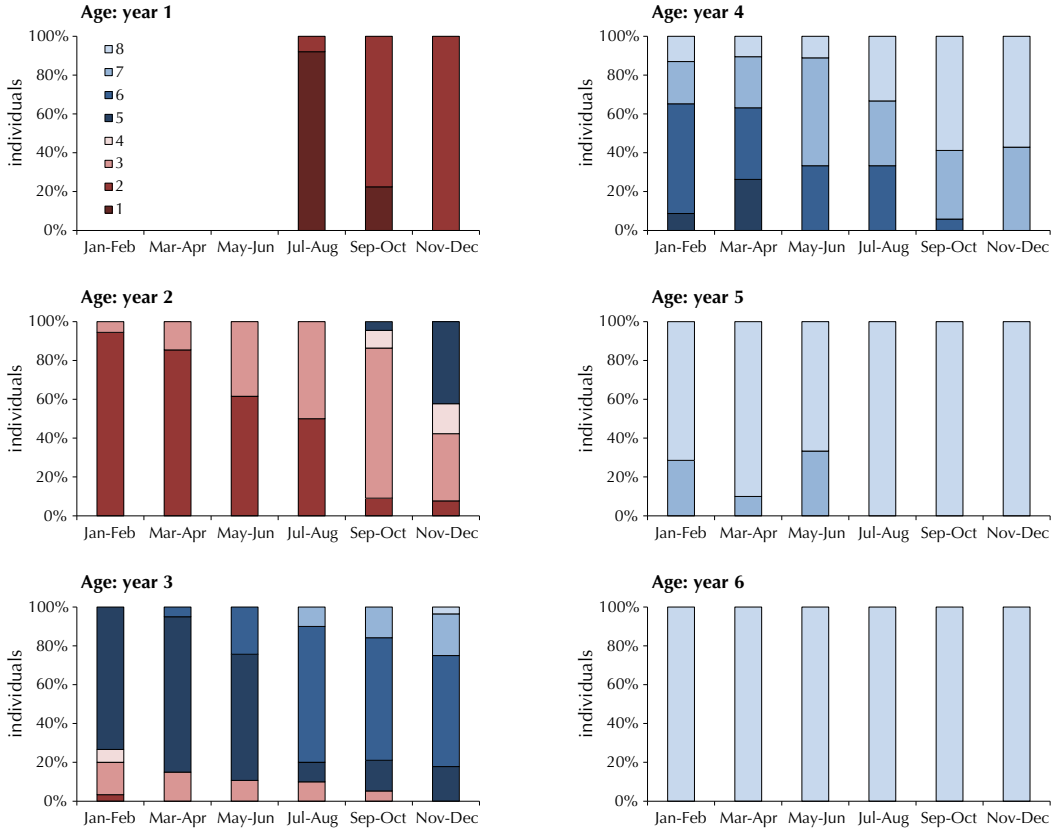

FIGURE 5 Seasonal replacement of distinct plumage patterns (type 1-8 from table 1; type 1 corresponds with juvenile plumage, type 8 with adult plumage) in a Yellow-legged Gull *Larus michahellis* population at Bay of Biscay, northern Spain; data pooled into two-month periods owing to sample size constraints.

months, from July of the third calendar-year to June of the fifth calendar-year. Finally, type 8 seemed to appear for the first time as early as at the age of 26 months (August of the third calendar-year), although it was generally not observed up to July-August of the fifth calendar-year (figure 5).

Discussion

This is the first study aiming to describe in detail the seasonal plumage sequence within a '*lusitanius*' population. We used a sample of 423 colour-ringed individuals (seen at 788 different occasions/months), ie, birds of known age, and the sample size per each category of plumage was acceptable. Therefore, we consider that the sample used in this work was representative for the population and that the results are, in consequence, solid.

The first seven immature plumages appeared during the first five years of life, with adult plumage being observed generally not before mid-summer of the fifth calendar-year. Overall, such a time schedule fits with previous publications, although we detected some remarkable variations in relation to what has been published for the species (Cramp & Simmons 1983, Olsen & Larsson 2004).

It is interesting to note that for the breeding period in the fifth year of life still a remarkable percentage (c 20%) of the birds had a subadult plumage (classified as type 7), which in some birds was found to appear as early as the summer of the third year of life but in others remained up to the summer of the fifth year of life. This result contrasts with literature assuming that adult plumages would be fully acquired by the fourth year of life (Olsen & Larsson 2004). The long-term persistence of signs of immaturity fits with a slow life

199 Yellow-legged Gull / Geelpootmeeuw *Larus michahellis*, Zaluaga, Pyrénées-Atlantiques, France, 2 January 2018 *(Asier Aldalur)*. Bird 2R2G during its fourth year of life (ie, third-winter), ringed as nestling on 27 June 2015. **200** Yellow-legged Gull / Geelpootmeeuw *Larus michahellis*, Ondarroa, País Vasco, Spain, 20 November 2017 *(Asier Aldalur)*. Second-winter with no grey feathers in mantle and wing-coverts. These kinds of bird would be assigned to type 2 plumage. Note, however, that whole plumage is new due to complete moult during summer of its second year of life.

201 Yellow-legged Gull / Geelpootmeeuw *Larus michahellis*, Ondarroa, País Vasco, Spain, 10 November 2017 *(Asier Aldalur)*. Typical second-winter, with some grey feathers in mantle and wing-coverts (type 3 plumage). Bird 8V1G was ringed as nestling on 1 July 2016. **202** Yellow-legged Gull / Geelpootmeeuw *Larus michahellis*, San Sebastián, País Vasco, Spain, 7 February 2016 *(Juan Arizaga)*. Typical first-winter, assigned to plumage type 2, with juvenile feathers in wing-coverts. Bird 8L2G was ringed as nestling on 25 June 2015.

history strategy (found in birds with delayed sexual maturity), characterized by high adult survival rates, a relatively low reproductive investment and high competition during the breeding period (either for sites and/or feeding sources) (Newton 1998, 2013). Exact causes underlying the persistence of these 'subadult' birds during their fifth year of life remain unknown to us, as it also remains unknown why a number of birds showed adult-like plumage already in their third winter, so this is something for future research.

Overall, the proportion of birds with adult-like plumages remained low (c 10%) up to June of the fourth calendar-year. However, adult-like plumages were still found during the third calendar-year (plate 199). We cannot exclude the possibility that part of these results could be due to a misclassification of the age of these birds, since small signs of immaturity might have gone unnoticed, especially in those birds which could not be photographed in flight. To be cautious, we recommend to consider this result as preliminary, as more work must be done in order to have incontestable proof of fully adult-like plumages in birds in their third winter (before their complete moult during the summer of their fourth year of life). In the near future it would also be interesting to test for possible differences between the pattern observed in the '*lusitanius*' population and other Yellow-legged Gull subspecies (nominate *L m michahellis* and *L m atlantis*), and the drivers explaining such possible patterns.

For immature plumages, it is noteworthy that type 2 plumages were detected up to January of the third calendar-year, which means that a quick look at some birds could result in a misclassification as 'first-winter' when indeed they are in their second winter (plate 200). Note, however, that these birds with no grey in the mantle and wing-coverts (type 2 plumage) have undergone a complete moult, hence feathers like their wing-coverts have a coloration (plate 201) different from that found in birds in their first winter, which retain juvenile feathers in the wing-coverts (plate 202).

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Samenvatting

Seizoensvariatie in kleur van verenkleden van Geelpootmeeuwen langs Golf van Biskaje, Spanje De seizoensvariatie in kleur van verenkleden van een residente populatie van Geelpootmeeuw *Larus michahellis 'lusitanius'* langs de Golf van Biskaje, Spanje, wordt in dit artikel nauwkeurig beschreven. De leeftijden van individuele vogels werden bepaald met behulp van kleurringen en er werden acht verenkleedcategorieën onderscheiden, waarvan de eerste zeven onvolwassen kleden in de eerste vijf levensjaren voorkwamen. In het algemeen werd het adulte kleed vanaf halverwege de zomer in het vijfde kalenderjaar vastgesteld. De resultaten kwamen overeen met die van eerdere publicaties maar we vonden een aantal opvallende afwijkingen. Het was vooral opmerkelijk dat c 20% van de vogels in hun vijfde jaar nog een subadult verenkleed droegen, terwijl andere exemplaren al in de zomer van hun derde jaar een adult verenkleed leken te hebben.

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