# Conservation status of Creole sheep flocks in Brazil

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**Abstract:** The Creole sheep (*Ovis aries*) is a transboundary breed that has been reared for centuries in southern Brazil, although it was officially recognized by the Brazilian authorities only in 2001. There are no updated local records on its current abundance, which is essential to establish conservation policies for the breed if required. Based on a survey conducted among farmers and considering all genealogical control records for Creole sheep provided by the Brazilian Sheep Breed Association (ARCO), we herein address the status of the breed in terms of the number and size of flocks, updating its geographical distribution. There are approximately 112 Creole flocks, totalling 8,844 reproductive ewes (flock size from 3 to 850 individuals; geometric average 54.77 individuals per flock). The flocks are primarily distributed in the southernmost states of Rio Grande do Sul and Santa Catarina, with sporadic occurrence in northern and central states (Rio de Janeiro, Minas Gerais and Goiás). The majority of the flocks (n = 105 flocks, with 8,298 ewes) are privately held, being reared primarily for meat and carpet wool production, similarly to other commercial breeds. A few flocks (5.61%) have remained with the same families, whose ascendants started rearing Creole sheep as an undefined breed over a century ago. However, over 65% of the current breeders have started rearing these sheep in the last two decades, following the official recognition of the breed and the foundation of the Brazilian Creole Sheep Breeder Association, which is in charge of breed promotion. Moreover, 73 flocks with genealogical control by ARCO have been established since the official recognition of the breed (total average = 427.80 specimens recorded per year). Recently, however, this number has decreased, with only 19 Creole breeders registering sheep in the last five years. Notwithstanding, the number of registered males remained stable (average of 78.2 rams/year, during 2016–2020). Taken together, the total number of the existing Creole ewes and males is well above the threshold adopted by the Food and Agriculture Organization of the UN (FAO) to qualify a given sheep breed as at risk ($<$ 80% pure-breeding ewes).

**Keywords:** Genetic resources, Transboundary breeds, Sustainability, *Ovis aries*

## Introduction

The Creole sheep (*Ovis aries*) breed has been reared for centuries in the southernmost Brazilian states of Rio Grande do Sul and Santa Catarina, Uruguay and Argentina (Fernández, 2000; Vaz, 2000; Gonçalves *et al*, 2010; Peña *et al*, 2013; Silva *et al*, 2013b; Moreira *et al*, 2021). Presumably, the breed originated from the early sheep introduced by the European colonizers into the region in the 1600s (Henkes *et al*, 1993; Mernies *et al*, 2007; Peña *et al*, 2013). Until recently, Creole sheep were considered the third most abundant sheep breed in Argentina (Peña *et al*, 2013, 2015) , although only a few flocks remain in Uruguay (Fernández, 2000). The Creole was the prevailing but uncharacterized sheep breed in southern Brazilian farms until the beginning of the 20$^{th}$ century when it started being replaced by other commercial breeds (Hervé, 1922). Supposedly, in 1982, given the threat of extinction, a conservation programme for Creole sheep was initiated in southern Brazil by the Brazilian Agriculture Research Corporation (EMBRAPA) (Vaz, 2000). The remaining breeders were locally identified, variations in the phenotypes of their sheep were evaluated, and the establishment of new Creole flocks was initiated. To promote the breed, the Brazilian Association of Creole Sheep Breeders (ABCOC) was founded in 1999 and immediately requested official recognition for the breed. In 2001, based upon a standard broad enough to encompass the wide range of phenotypic variations existing in the corresponding flocks in southern Brazil at the time, Creole gained recognition as an official breed (Vaz *et al*, 2002, 2003).

Subsequently, the corresponding genealogical control of this newly recognized sheep breed was delegated to the Brazilian Association of Sheep Breeders (ARCO).

At the end of the last century, the number of Creole flocks was estimated to be 52 within the Rio Grande do Sul state, with approximately 5,000 individual sheep (Vaz, 2000). Since then, however, there have been no efforts to further examine the temporal changes in the number of existing flocks in general, except for those affiliated with ARCO. According to McManus *et al* (2014), the total number of such affiliated flocks was 65 at the end of the first decade of the present century. However, there is no numerical limit for the registration of a given flock. Also, in such a study, no information is given on the number of animals registered. Moreover, affiliation with ARCO is optional for the sheep breeders, and once registration starts, breeders can stop registration at any time while still maintaining the affiliation. According to the 'Domestic Animal Diversity Information System,' the breed is listed as "at-risk" ("vulnerable" category), based on the estimated population size of 5,422 individuals in 2018 (FAO, 2021). However, the process by which this inventory was conducted is not known. Thus, there is a lack of updated information on flocks that are actively supervised by the ARCO as well as the unsupervised flocks. Unsupervised flocks are thought to be more numerous than those under ARCO's supervision. This population information is important not only to monitor the numerical performance at the spatiotemporal scales but also to propose future conservation policies for the breed, if necessary.

Creole sheep are medium-sized animals, with the smallest body size among other commercial breeds reared in the region. Morphometric data provided by Mernies *et al* (2007) and Moreira *et al* (2021) indicate that meat production is the main attribute, rather than milk production. Meat production may be an important commercial alternative for this rustic, behaviorally active and naturally adaptive sheep. Although not evaluated in terms of the organoleptic properties, Creole sheep meat is traditionally recognized as being tasty and light. Creole sheep can be recommended for low-tech breeding systems, as the animals are adapted to mountainous areas, where comparatively sparse quality pastures grow (Fernández, 2000; Mernies *et al*, 2007; Peña *et al*, 2013; Moreira *et al*, 2021). Recent studies have highlighted that Creole lambs finished in feedlots responded satisfactorily to low-cost concentrates, such as the by-products of the rice industry, while still producing high-quality carcasses when supplied with dressing percentages varying from 46.36% to 53.26% (Matos, 2016; Oliveira, 2016). In addition to purebred lambs, progeny obtained by crossing the F1 animals with other commercial breeds (e.g. Suffolk) and reared on pasture reached a suitable size for slaughtering, since relatively small sheep carcasses (14–16 kg) are currently in demand in the region (Matos, 2020, 2021). Overall, the preliminary observations indicate that such aspects that

are supported by the ABCOC affiliates are turning Creole into a more popular breed, leading to a substantial increase in the number of animals.

In the present study, changes in the population size of this sheep breed are analyzed in space and time. A survey among Brazilian Creole sheep breeders first listed and mapped the currently active Creole flocks in the country. This was followed by documenting the variations in the age of the flocks and the number of individuals per flock. Finally, the Creole flock book records were assessed to explore variations in the number of registered animals throughout the existence of Creole as an official breed.

## Material and methods

A general survey was conducted between June and July 2021. The ABCOC data bank was used to identify Creole breeders, to whom two questions were individually asked in formal interviews: (1) For how long have you (or your ancestors) been continuously breeding Creole sheep, independently of being genetically controlled or not? (2) What is the number of ewes present in your Creole flock at present? A list of such flock owners (or managers), along with the size of their flocks and municipalities, is presented in Supplemental Data 1. Their phone numbers and farm names are available at www.ovelhacrioula.com.

Data for the genealogy-controlled flocks were retrieved from the ARCO data bank. Specifically, these data correspond to the annual records for all Creole sheep breeders who have been consistently affiliated with ARCO throughout the official existence of the breed (2001–2020) (Supplemental Data 2). For such flocks, both sex and pedigree ranks were included in the census. According to ARCO's rule applied to local breeds, the individuals of a given non-controlled flock are initially registered within a specific category called the 'Brazilian Genealogical Registration' (RGB). The non-affiliated individuals that meet the phenotypic breed standard are registered for the first time as $RGB_{base}$. Such individuals only reach purebred status (PO) after continuous ARCO-controlled breeding until the fifth generation, that is, after passing across the $RGB_1$ to $RGB_4$ categories. In the case of Creole sheep, the first PO animals appeared in 2005. However, RGBs are being registered even today, because the breed flock book remains open; that is, Creole is still under development and is still open to the inclusion of previously unregistered but typical sheep.

## Results and Discussion

The survey retrieved 112 Creole flocks, totalling 8,844 reproductive ewes (Supplemental Data 1). The number of ewes per flock varied from 3 to 850 (geometric mean = 54.77). The corresponding frequency distributions were biased toward small numbers, with over 50% of the flocks comprising fewer than 40 individuals (Figure 1A). Creole flocks are primarily distributed in Rio Grande do Sul (76%) and Santa Catarina (22%) states, with

sporadic records in Paraná, São Paulo, Rio de Janeiro, Minas Gerais, and Goiás (Figure 2). Flocks varied in age from 1 to 180 years (Figure 1B). A few flocks (n = 6) were centenarians, whereas over 65% of flocks were below 20 years of age, with approximately half (n = 31) of the latter being younger than 5 years. The majority of the flocks were maintained by private owners (93.75%), and the remaining few were owned by public agencies, including federal, state or municipal institutions involved in research and/or education.

Compared with the original data reported by Vaz (2000) at the end of the last century, the number of Creole flocks is more than double at present, although the average size of each corresponding flock is approximately half. Although the precise reasons underlying this trend remain unknown, it is likely explained by an overall loss in the value of sheep breeding in the region, which has been greater than that of other rural activities, such as soybean cultivation and forest plantations. Silva _et al_ (2013a) demonstrated that sheep breeding in the Rio Grande do Sul qualifies as the secondary exploitation of farms, with small flock size and subsistence being the primary objective. The exponential increase in the number of Creole flocks, resulting primarily from private investment, demonstrates the importance of the development activities exercised by ABCOC and public institutions in attracting new breeders. For instance, ABCOC has effectively encouraged breeders to participate in the major farm fairs in the region, such as EXPOINTER, which is held annually in the Esteio municipality of Rio Grande do Sul and is considered to be the largest livestock show in Latin America (Moreira _et al_, 2021). ABCOC has prioritized activities aimed at garnering public attention to breed rusticity and the associated breeding attributes and cultural significance as well as the various Creole products, such as high-quality meat and long-staple, colourful wool specifically for use in the production of carpets and other handcrafts (Matos, 2020, 2021; Trierweiler, 2021).

According to the Food and Agriculture Organization of the UN (FAO, 2013), there must be a minimum of 7,200 breeding females to qualify a given sheep breed as being not at risk. Currently, the number of breeding Creole ewes within the Brazilian borders is above this threshold. Moreover, there has been an exponential increase in the number of flocks and expansion in their distribution to the states further north. As such, most of the young flocks have been established recently with specimens from southern Brazil (Moreira _et al_, 2021). Importantly, Creole is a transboundary breed (FAO, 2015), with a relatively high number of flocks in Argentina and Uruguay, as mentioned above. Those flocks are not considered in the present study. Thus, from the viewpoint of population size, the breed is far above the risk threshold in a broad geographic sense. However, other factors should also be considered when determining the degree of endangerment from a conservation perspective of a given breed, such

as localized distribution (Carson _et al_, 2009). Many Brazilian flocks are located far apart from one another because this sheep breed is widespread in southern parts of South America. As a result, the Creole may eventually face the risk of local extinction (McManus _et al_, 2014), albeit with a low impact on the general integrity of the breed. Although not taken into account in our survey, we estimated the total number of reproductive rams existing among the overall Brazilian Creole flocks to be ca. 177, since the ratio of one adult ram to 50 reproductive ewes is expected for the breed (Moreira _et al_, 2021). In other words, results suggested the number of reproductive males also goes beyond the defined thresholds established by FAO. However, these data have been retrieved from non-registered flocks, falling into the '< 80% pure-breeding ewes' category established by FAO (2013), and thus the number of registered rams should also be considered to determine the risk status for Creole sheep, as discussed further below.

The cumulative number of Creole breeders affiliated with ARCO throughout the existence of the breed was 73 (Supplemental Data 2). The number of flocks registering sheep in the book varied from 6 to 25 per year (mean = 13.6 per year). The total number increased in the initial years since recognition, reaching a peak in 2009 (Figure 3A, Supplemental Data 2), but it declined progressively until 2014, following a plateau thereafter until the present time. The cumulative number of Creole animals registered by the ARCO has reached 8,918 in two decades (Supplemental Data 2). The total number of newly registered animals varied from 137 to 828 per year. The distribution of this number over time (Figure 3B) followed a consistent trend, varying proportionally with the number of flocks registered in each year ($y = 34.61x - 43.6$; $n = 20$; $r = 0.83$; $p < 0.001$). This pattern can be explained by the balance between the number of Creole breeders entering and leaving the registration over time. The number of breeders who started registering their flocks at ARCO continued to increase progressively (Figure 3C), albeit with a simultaneous increase in the number of breeders with interrupted registration (Figure 3D). Only 19 breeders have consistently registered one or more animals in the flock book in the last five years. Of the 73 flocks with animals that were registered with ARCO, only 32 (28.57%) were active with certainty (Supplemental Data 2), among the list of flocks presented in Supplemental Data 1. That is, approximately two-thirds of the corresponding flocks either do not exist anymore or information on whether they are active at present is missing. Of note, however, there has been an increase in the proportion of males registered; as such, rams accounted for 391 records in the last five years (average = 78.2 rams registered per year; Supplemental Data 2). It is worth also mentioning that EMBRAPA registered many more animals than anyone else, which may lead to a narrowing of genetic participation in the next generations. If this is flowing
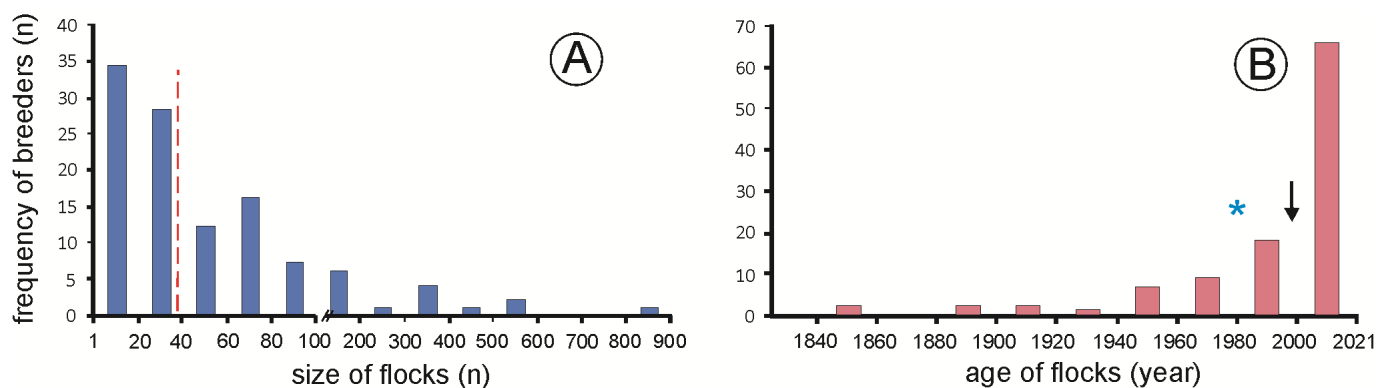
**Figure 1.** Frequency variations in the number of ewes per flock (A) and the year of Creole sheep flock creation (B) in Brazil, based on a survey among Creole sheep breeders conducted from June to July 2021. A list of breeder names and municipality/state, age, and size of the corresponding flocks are provided in Supplemental Data 1. The dashed line (A), asterisk, and arrow (B) indicate, respectively, the statistical median, the beginning of Creole sheep conservation programme by the Brazilian Agriculture Research Corporation (EMBRAPA), and the foundation of the Brazilian Association of Creole Sheep Breeders (ABCOC).
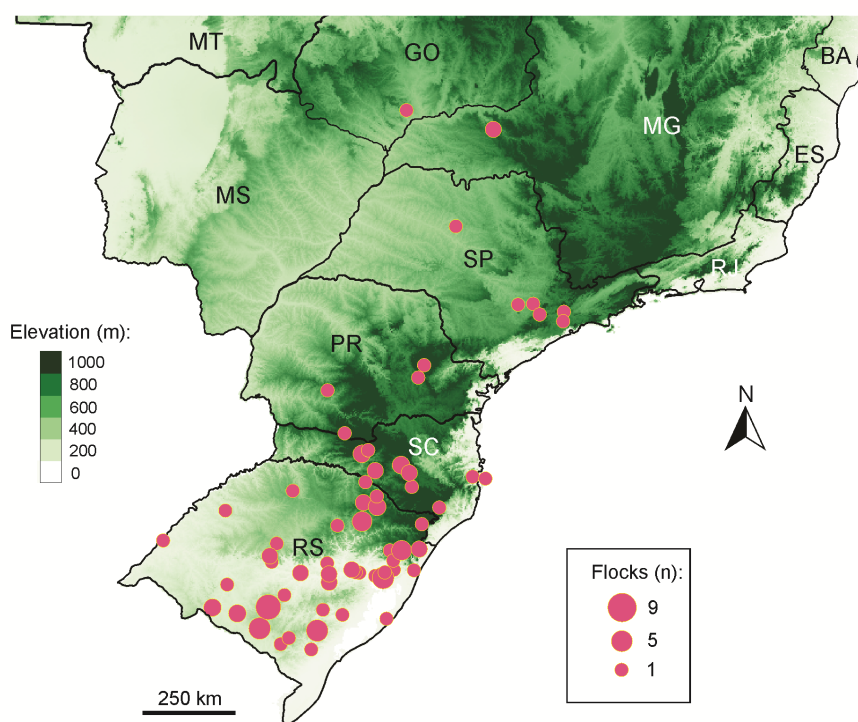


**Figure 2.** Geographic distribution of Creole sheep flocks in Brazil (n = 112). BA, Bahia; ES, Espírito Santo; GO, Goiás; MG, Minas Gerais; MT, Mato Grosso; MS, Mato Grosso do Sul; PR, Paraná; RJ, Rio de Janeiro; RS, Rio Grande do Sul; SC, Santa Catarina; SP, São Paulo. Farms were distributed according to municipalities, a list of which is presented in Supplemental Data 1. The corresponding geographic coordinates were obtained from Falling Rain Genomics (2007).

out into the unregistered flocks, then there may be a problem in that they are being absorbed and replaced rather than contributing to the maintenance of the genetic resource, which should be further explored.

Registration is fundamental in a given conservation programme because it acts as a continuous filter to maintain the breed's integrity by excluding animals that are used for crossing with other breeds as well as the newborns that are not eligible for registration. As already pointed out by Alderson (2009), registration also captures the eagerness and conviction of breeders

for the breed they farm. By being associated with rural traditions and the history of many families in the region, as demonstrated by the old age of several flocks estimated herein, Creole breeders are usually committed to the conservation of this breed and are passionate and proud of it. In this context, the decrease in registration may be attributed in part to the death of the owners, following which the successor family members did not continue the flocks. Others may have simply changed their preference, quitting Creole breeding and starting to rear a different breed. Particularly in the northeast of
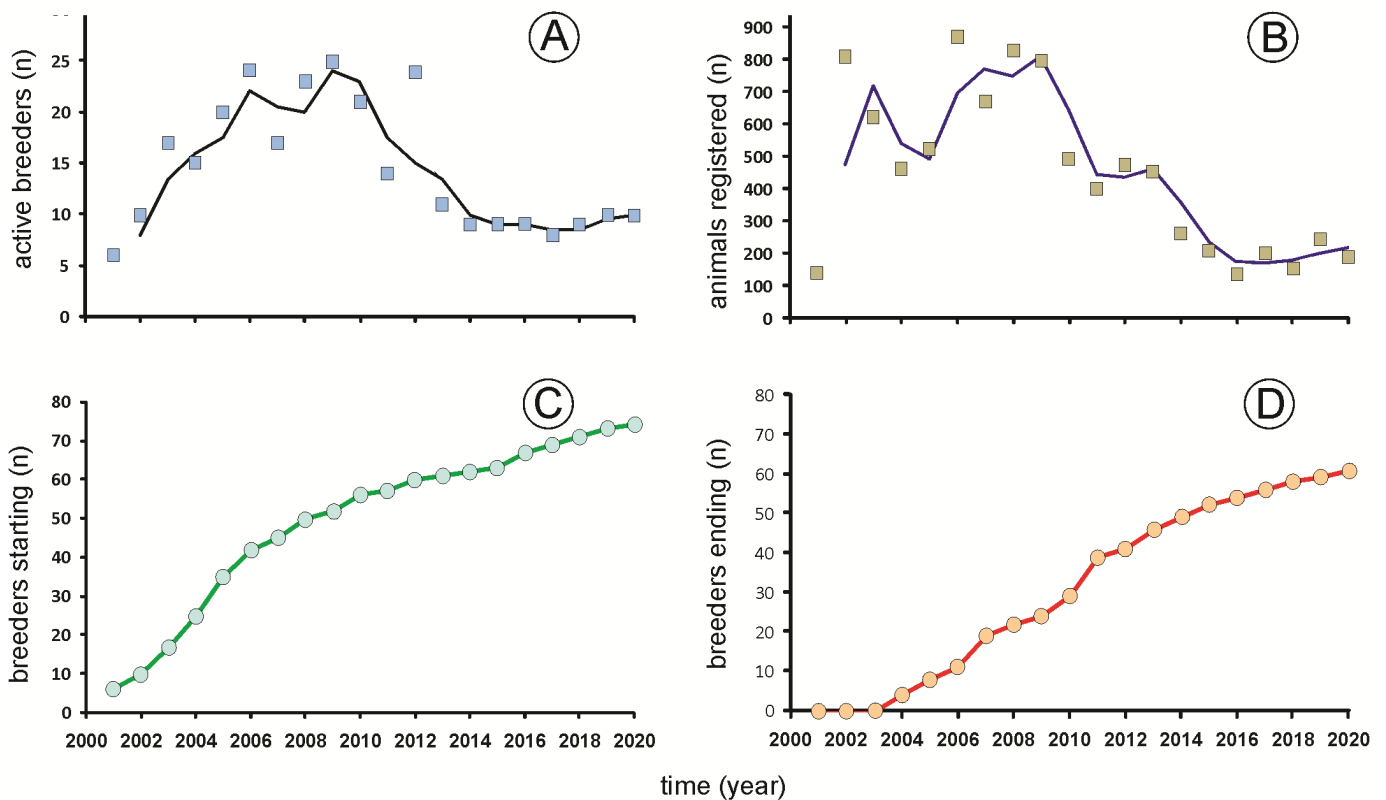
**Figure 3.** Annual variations in the number of Creole sheep breeders (A) and animals per flock (B) registered annually at the Brazilian Sheep Breed Association (ARCO) in the present century, and the cumulative number through the period of breeders starting (C) and ending (D) registration in the flock book. Breeders specifically affiliated with ARCO, along with the number of sheep registered each year in the Creole flock book, are listed in Supplemental Data 2.

Rio Grande do Sul, several breeders have likely stopped sheep breeding in general due to the harm caused by the attacks of cougars, wild boars and domestic dogs. However, many argue that registration does not pay off because ARCO's costs are relatively high and the Creole is a low-price sheep. Thus, breeders simply stop registering their sheep after a certain time of affiliation with ARCO, and most never register them. From a conservation perspective, this decrease has somewhat attenuated since the proportion of males registered remains high, being well above the threshold of 35 males adopted by FAO (2013) (< 80% pure-breeding ewes) for species of low reproductive capacity, such as sheep. As already mentioned, the Creole breed predates such records provided by ARCO. Given the relatively low registration numbers, it remains unknown whether the Creole flock book really captures the breed and its genome, or whether most of this lies outside of the official records.

## Conclusions

The population size of the Brazilian Creole sheep has increased substantially in the present century, surpassing the threshold established by FAO (2013) for endangered sheep breeds worldwide; thus, Creole does not qualify as an 'at-risk' breed ('vulnerable' category). The breed is primarily reared in the states of Rio Grande do Sul and Santa Catarina, with few flocks in the northern and central parts of Brazil. This surge was achieved following the initiation of a conservation programme for Creole by EMBRAPA in 1982 and the foundation of ABCOC in the late last century. The resulting efforts were followed by the official recognition and beginning of the genealogical control of the breed conducted by ARCO in the early present century. This is an example of how public institutions and private farmers can join efforts to successfully save a sheep breed from extinction and substantially improve its population size within a few decades. Thus, as a breed that is not a risk, Creole sheep warrant further improvement as a breed FAO (2015).

## Supplemental Data

Supplemental Data 1: Breeder names and municipality/state, age (years since the flock creation), and size (number of ewes) of the corresponding Creole sheep flocks between June and July 2021.

Supplemental Data 2: Number of animals registered by breeders per year in the Creole sheep flock book from 2001 to 2020 at the Brazilian Association of Sheep Breeders (ARCO), including both the Brazilian Genealogical Registration (RGB) and Purebred (PO) categories.

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## Conflict of interest statement

The author declares that no conflict of interest exists.

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