# Chemical horn infusions: a poaching deterrent or an unnecessary deception?

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## Abstract

Poaching for horn remains a significant threat to rhinos. Conservationists use various approaches to deal with the threat. One method advocated is infusing rhino horns with chemicals and dye. Promoters of this method claim the procedure renders the horn useless and that ingesting poisoned horn carries potential risk to the end-user. We visually examined white rhino horn that had been treated; we examined available literature; and we obtained expert opinion to assess several assumptions and risks associated with the approach. We found the information on which the assumptions are based to be weak, and refute claims that discolouring horns is a viable method. Our assessment contests the efficacy of this technique on conceptual and logistical grounds, especially when dealing with relatively large populations. We argue that conservationists should not use this technique to deal with the rhino poaching threat.

## Résumé

Le braconnage pour la corne reste une menace importante pour les rhinocéros. Les écologistes utilisent différentes approches pour faire face à la menace. Une des méthodes préconisées est l'infusion des cornes de rhinocéros avec des produits chimiques et des colorants. Les partisans de cette méthode affirment que cette procédure rend la corne inutile. Cependant, elle comporte également un risque potentiel à l›utilisateur final quand il ingère la corne empoisonnée. Nous avons examiné visuellement la corne de rhinocéros blanc qui avait été traitée, et nous avons examiné la documentation disponible et obtenu l›avis des experts pour évaluer plusieurs hypothèses et les risques associés à la démarche. Nous avons trouvé que l›information sur laquelle les hypothèses sont fondées n'était pas correcte, et nous réfutons les allégations selon lesquelles la décoloration des cornes est une méthode viable. Notre évaluation conteste l'efficacité de cette technique pour des raisons conceptuelles et logistiques, surtout lorsqu'il s'agit de populations relativement importantes. Nous soutenons que les écologistes ne doivent pas utiliser cette technique lorsqu'ils sont confrontés à la menace du braconnage de rhinocéros.

## Introduction

Poaching continues to threaten rhinos despite intensified anti-poaching campaigns (Ferreira et al. 2012). Evaluation of multi-pronged approaches that include reducing demand, providing horn and eliminating poaching through intensified anti-poaching campaigns (Ferreira and Okita-Ouma 2012) illustrates that integrating approaches carries the largest benefits for a suite of conservation outcomes (Ferreira et al. 2014). Some options, such as providing horn through legalized trade, are, however, not available at present (Child 2012; Biggs et al. 2013).

The international call for intensified protection of rhinos through traditional anti-poaching measures may fail to curb illegal killing because the incentives of financial benefits outweigh the disincentives (see Ferreira et al. 2014). Rangers' efforts require matching initiatives directed at disrupting transnational crime networks, at a scale conservationists have never before faced (Dalberg 2012). Authorities may also reduce supply through approaches such as treating live rhino horn chemically to make it unfit for human consumption (Rhino Rescue Project 2013). Typically, horn treatment is infusing a compound or a combination of compounds into the horn of a live rhino. The most common infusion comprises an indelible dye and a deposit of ectoparasiticides (Rhino Rescue Project 2013). The effectiveness of horn treatment as an added disincentive for rhino poaching is unknown.

Here we consider the strategic context and conceptual basis for reducing poaching through direct deterrence by the chemical itself, or indirect deterrence of making poachers believe that the horn has no value, through publicizing horn infusions. Second, we highlight legal and ethical challenges. Third, we focus on the scientific basis of the potential of chemical deterrence, and the efficiency and maintenance of its application. We also consider the logistical requirements of infusing a large number of rhinos in a population. Reduction in poaching rates, however, is the ultimate measure of success. We check whether this occurs.

## Conceptual challenges

The concept of infusing chemical substances into rhino horns in an attempt to reduce poaching is based on a number of assumptions. It presupposes that the infused chemicals provide discomfort to an end-user consuming the treated horn (Rhino Rescue Project 2013). Where infusions comprise indelible dye as well, proponents predict the horn will be considered as worthless for ornamental use. The belief behind such chemical treatments is that it devalues the horn and thus makes it unmarketable. A key element as part of such an initiative is the assumption that wide-scale publicity of chemical treatment of horn will deter poachers.

Prices paid to poachers for horn provide significant financial incentive (Ferreira et al. 2014), which relates to the demand and supply that sets commodity prices at a particular time. Anti-poaching programmes, dehorning (Lindsey and Taylor 2011) or chemical treatments (Rhino Rescue Project 2013) aim to provide equal or higher disincentives. Infusionists assume that poachers will not be able to sell the treated horns to end-users as they would be considered unsuitable, thus reducing the demand for them and thus reducing their financial value. Removing the financial incentive would result in disincentives outweighing incentives and poaching rates would therefore decline (Ferreira et al. 2014).

A key challenge arises, however, because infusing would create two rhino horn commodities—treated and untreated horn. Increasing the supply of treated horn (or horn perceived to be treated), assumed to have no value and thus no demand for them, reduces the supply of untreated horn (whether real or perceived), causing a growth in demand (Milliken and Shaw 2012). Reducing the supply of untreated horn will escalate prices and simultaneously increase poaching incentives. It implies a threshold requirement of a proportion of treated horn in a population large enough to make it not viable for poachers to seek untreated horn. Such a threshold should eliminate the supply of untreated horn, real or perceived. If there is no supply of untreated horn even though demand remains, economic dynamics predict no price. Completely removing the supply of untreated horn is highly unlikely because lingering demand will likely generate illegal suppliers to design innovative ways of providing horn (e.g. high-pressure chemical washing of horns). The pet trade experienced this innovation dynamic with cybercrime becoming a key element of wildlife trafficking in response to enforcement of CITES resolutions (e.g. Izzo 2010). The example illustrates the potential of illegal supply innovation to derail the market disruption strategy. Demand and supply interactions predict rapidly escalating prices for untreated horn and consequently, increased poaching incentives (Jain 2006).

It is likely that there will be no effect on poaching rates because poachers ignore, or are not aware of, the difference between treated and untreated rhino horn, and additionally because poachers are not the end-users. Therefore, there is no reason for treated horn not to be sold, especially if the chemicals are not visible. In addition, corrupt sellers abound in the horn trade—many fake horns are in circulation and knowingly sold at high prices (Milliken and Shaw 2012). Typically, suppliers seek to sell their product at the highest price and the illegal market does not follow processes based on honest and true facts (Natarajan and Hough 2000). This situation, however, has no effect on supply-and-demand dynamics (Jain 2006) and hence no effect on price incentives for poaching.

Supply-and-demand dynamics (Jain 2006) predict a similar outcome as above if poachers are unaware of chemically treated horn. Publicity that convinces poachers that a whole population comprises only treated rhinos can potentially counteract this outcome. Such an approach is likely to achieve some degree of success on small reserves, but less so in large areas. Even if poachers are aware of infusions, they may not be able to recognize chemically treated horn. For instance, blood, skin, mud and normal wear of the horn may make it difficult for a poacher to recognize a compromised product.

Some of these consequences are easy to mitigate when focusing on one small reserve, in isolation from the broader context of the complete rhino population. Demand–supply models (Jain 2006) predict that a new supplier or an existing supplier replaces the product missing after an established supplier is removed, if demand is high enough. This dynamic may explain why daily poaching rates in South Africa increased after pseudo-hunting (non-bona fide hunters hunting rhinos as sport hunters, South African Department of Environmental Affairs, unpublished data) was abolished. Outcomes for small reserves disregarding wider implications may thus actually stimulate poaching in other areas.

These varied consequences challenge the assumption that horn treatments reduce demand because it disrupts the supply. Reduction in demand for unspoiled products does not result because of spoiled end-user products (Jain 2006). None of the demand-reduction theories proposed was tested before being implemented, including the effect of infused horn on humans. This effect will be difficult to ascertain; because the use of rhino horn is not legal in end-user countries (Milliken and Shaw 2012), it would be difficult to obtain reliable information on the health outcomes of horn use. The underlying assumptions and subsequent consequences of horn infusions thus introduce complexity that carries uncertainty for curbing rhino poaching. Horn infusions only re-arrange the supply axes, but the demand remains.

## Legal and ethical challenges

A key legal risk is whether third parties suffer harm, loss or injury resulting from using treated horn. However, the single known existing legal opinion in this regard (available from the Rhino Rescue Project 2013) indicates no criminal or civil implications. The opinion makes use of rules of exception to the *par delictum* rule (the plaintiff cannot be successful in a claim when the plaintiff's own actions were unlawful) and argues that the action to treat the rhino horn is not unlawful because it is primarily aimed at the health and wellbeing of the animal. We could find no published scientific support for this statement. In addition, poaching and most trading in rhino horn are illegal in most countries (CITES 2010, 2011), but whether it is illegal to consume it is uncertain. If authorities allowed legal poisoning of illegal substances, widespread application to reduce worldwide illegal drug trades should result—an outcome never realized. The end consumers would most likely become the plaintiffs, some of whom received horns as gifts or bought them legally as traditional Eastern medicine (Milliken and Shaw 2012). This introduces uncertainty that could remove the *par delictum* rule exceptions and introduce criminal or civil liability.

Cultural rights dilemmas may also be associated with horn infusions. Key stakeholders within the countries with the highest number of consumers have expectations that the global community respects specific cultural traditions. Treating horn chemically may act as customary rights discrimination (e.g. Fougere 2006), a risk that directly contrasts with several CITES resolutions at recent Conferences of Parties (Cooney and Abensperg-Traun 2013). In contrast, stakeholders living in rhino range States expect that authorities will protect rhinos and effectively fight crime. Infusing horns as a poaching deterrent may thus contribute to expectations of having a society with limited crime (Knight 2011), even if it only translates into illustrating a response. In such a case, the value would be temporary because range State stakeholders would also expect poaching rates to be reduced.

Animal welfare is also an important consideration (e.g. Bonier et al. 2004). Horn infusions use high-pressure systems (9-bar) to permeate the chemicals into the horn (Andrew Parker, pers. comm.[1]). Welfare consequences are notoriously difficult to evaluate and typically rely on behavioural indicators such as displacement activities and repetitive behaviours (e.g. Carlstead et al. 1993). We could find no formal evidence of behavioural assessment of either pretreatment vs. post-treatment, or control vs. experimental comparisons.

An immediate health risk to the rhino is associated with immobilizing the animals, with anaesthesia procedures resulting in at least one white rhino dying during the horn infusion process (Beeld 2013). Experience of immobilizing rhinos to notch ears, translocate or treat injuries suggests that the typical 30 minutes to complete the process (Rhino Rescue Project 2013) would be considered long (personal observation). In addition, it does not include effects of chasing rhinos during the actual darting. At least one study illustrated that immobilizing rhinos for translocation introduced elevated levels of stress (Linklater et al. 2010). In rhino-holding facilities, 5–10% of rhinos fail to adapt to boma conditions

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following capture (South African National Parks [SANParks], unpublished data[2]). Multiple captures of rhinos, particularly young rhinos, may carry chronic stress consequences given requirements of retreatment every 3–4 years (Rhino Rescue Project 2013). Horn infusionists anecdotally reported no detrimental effects on rhino health following capture for treatment (Rhino Rescue Project 2013), but no formal evidence is available.

A key concern is contamination of growth tissue at the base of the horn. The procedure uses a high-pressure system to force chemicals into hard horn; infusing the soft tissue would be simpler but may result in damage to the growing tissue. We could find no literature as to the effect on it. Neither could we find literature that described health benefits from infusing as an ectoparasiticide treatment, although topical application of medication has been used for wound treatments on hooves. Effectiveness of such treatment is still debated in the veterinary field (Johan Marais, pers. comm.[3]). Given that the infusion with ectoparasiticides focuses on the internal horn tissue, it is unlikely that there will be any noticeable health benefits to the rhino. Even so, conservationists need several clinical trials to evaluate its effectiveness on rhino health. Such an evaluation should include the consequences of disrupting parasite–host interactions. We could find no evidence of such evaluation before or after the commercial launching of the infusion product.

## Science challenges

Conservationists strive to adhere to a philosophy of strategic adaptive management (Roux and Foxcroft 2011) and place great value on robust science-based decisions (Roux et al. 2012). Some of the scientific assumptions that infusionists make warrant evaluation.

### *Chemical deterrence potential*

Hazard identification of the composition of the most common treatment (i.e. combination of ecto-parasiticides and indelible dye) highlighted that the dye may cause eye, skin and respiratory tract irritation and could be harmful if swallowed, inhaled or absorbed through the skin (document provided by Peace Parks Foundation[4]). It is unclear what quantities end-users need to consume before the effects become acute. We could find no evaluation associated with the depository of ectoparasiticides. These comprise freely available over-the-counter antiparasitic drugs used to treat ectoparasitic infestations where parasitic organisms primarily live on the surface of the host (defined by Rhino Rescue Project 2013). The exact ectoparasiticide combinations are unknown, with no human health risks defined. Most commercially available ectoparasiticide products are relativity safe to humans and unlikely to have any serious health consequences for end-users in the quantities ingested from known rhino horn products (Johan Marais[5] and Gerhard Steenkamp[6], pers. comm.).

Although the chemical combination may carry discomfort, we could not find literature that indicates some part of an animal infused by similar compounds (usually used for treating horse hoofs, Johan Marais, pers. comm.[6]) is toxic to humans. Drugs used to treat animals followed by subsequent consumption of meat with residual hormonal and medical drug residues resulted in affecting a small percentage of persons (US Board of Agriculture 1999). It is unlikely that end-users will notice an acute effect, because rhino horn for medicinal purposes comprises only small doses mixed with other substances.

In addition, it is assumed that people will not refrain from consuming something if they perceive it to have medicinal or delicatessen value, even if it is potentially highly toxic. Fugu, or the puffer fish, are highly poisonous and contain tetrodotoxin, a potent neurotoxin (Tsang and Tang 2007). Yet it is a highly valued delicacy in China and Japan, even though a number of people eating it die every year (Bingbin 2012).

### *Application efficiency*

Rhino horn is essentially papillary cornified epidermis (Hieronymus et al. 2006); it comprises a composite material with tubules of keratinocytes forming fibres embedded in a resin-like matrix of varying composition. Calcium phosphate salts, most likely hydroxyapatite or octocalcium phosphate, and melanin

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characterize matrix composition (Hieronymus et al. 2006). Rhino horn has a density of 1.26 g/cm$^{-3}$ (Pienaar and Hall-Martin 1993) with the horn tip slightly denser than the base. When sliced, a polished rhino horn resembles perspex, or poly-methyl-methacrylate, which has a density of 1.18 g/cm$^{-3}$ (makeitfrom.com 2009). More heavily melanin-pigmented cornified epidermal tissue occurs in the central longitudinal core of the horn (Figure 1). Most importantly, the variations in melanin content and calcification result in differential wear, the key mechanism for horn shape (Hieronymus et al. 2006).

Infusing rhino horn is not complex. Veterinarians immobilize a rhino using standard veterinary techniques (Standard operating procedures for capture, handling and transport of wild animals,SANParks[7]). After the rhino is successfully immobilized, holes (~10 mm in diameter) are drilled into the centre of the horn and an applicator is inserted. A compressor fitted to the applicator infuses the chemical combination under 9-bar pressure for 20 minutes (Andrew Parker, pers. comm.[8]). After the procedure, the applicator is removed, the hole plugged with a resin, and veterinarians administer an antidote to the rhino to recover from an anaesthetic drug.

We could find no literature assessing the efficiency of this procedure in distributing chemical compounds evenly through the cornified epidermal tissue of horn. Horn structure suggests differential resistance to wear (Hieronymus et al. 2006), which predicts differential distribution of the chemical compounds following infusion. Neither could we find literature on high infusion pressure that could damage keratinocyte tubules with consequences for the future strength of the horn. Even so, higher core melanin concentration (Hieronymus et al. 2006) predicts weaker treatment penetration in the longitudinal centre of the horn. There is thus some chance that suitable core areas remain and are still available for human consumption. When queried on this issue, the Rhino Rescue Project indicated that they had not cut through a treated horn to ascertain if the coloured dye actually infused through the horn as they claimed.

Samples from five sets of white rhino horns retrieved after horn infusion with indelible dye combined with ectoparasiticides (SANParks: 1 anterior and 1 posterior transverse cut; Sabi Sand Game Reserve: 1 anterior and 1 posterior transverse cut; Ezemvelo KZN: 3 anterior and 3 posterior drilled samples 1 month after infusion[9]) noted no visible discoloration through the papillary cornified epidermis of the horn (Figure 2). Even if there is not a formal test for ectoparasiticides or their metabolic derivatives in the papillary cornified epidermis, they are unlikely to be present given the chemical mixture of ectoparasiticides with indelible dye as part of the application procedure, and the fact that the indelible dye did not penetrate into the horns. All evidence indicates wide-scale failure of the application.

Figure 1. Polished back-lit cross slice through an anterior horn of a white rhino showing the more heavily melanin-pigmented cornified epidermal tissue in the core of the horn.

## *Maintaining deterrence effectiveness*

Even if one disregards application efficiency, maintaining deterrence effectiveness may be challenging. Rhino horn continually grows (Pienaar et al. 1991; Rachlow and Berger 1997; Hieronymus and Witmer 2004) at a near-constant rate throughout the areal extent (Hieronymus et al. 2006). This means that new cornified epidermis is laid down continuously at the base of the horn. Anterior (nasal) horns grow at 5–6 cm per year (Pienaar et al. 1991; Rachlow and Berger 1997) while posterior horns (i.e. the small horn behind the nasal horn) grow at 2 cm per year (Rachlow and Berger 1997).

Infusionists advocate treatment effectiveness for

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9 Data provided by Dave Cooper, Ezemvelo KZN, dcooper@kznwildlife.com

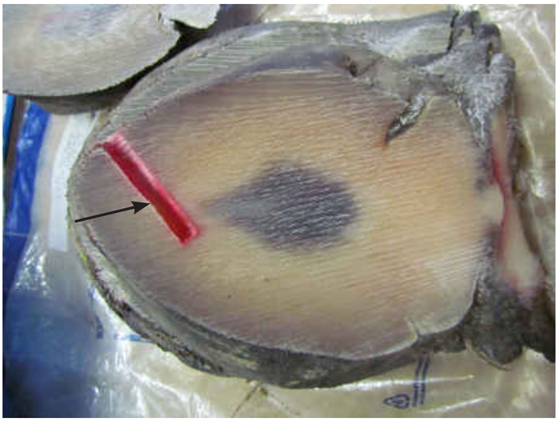

Figure 2. Transverse cut through a recovered posterior horn after infusion with a mixture of indelible dye (shown with arrow) and ectoparasiticides illustrating failure of the procedure to distribute the dye evenly throughout the papillary cornified epidermis of a white rhino horn. This result is characteristic of all horns sampled after the infusion treatment.

3–4 years (Rhino Rescue Project 2013). Horn growth adds new horn each year (Pienaar et al. 1991; Rachlow and Berger 1997; Hieronymus and Witmer 2004). Horn structure with hardness provided by calcification in melanized cornified epidermis (Hieronymus et al. 2006) suggests that the new cornified epidermis is unlikely to be affected by passive diffusion of the chemical compounds. In addition, horn wear determines horn shape and size (Boas 1931) with the higher concentration of melanin and calcium salts in the centre of horn determining the overall conical shape of rhino horn (Hieronymus et al. 2006). A full horn growth cycle is thus likely to be variable and impose uncertainty in the planning and requirements of repeat treatments to sustain apparent efficiency. Furthermore, the interactions between new cornified epidermis being continuously added and wearing rates being higher for treated parts of the horn suggest that untreated cornified epidermis will comprise larger and larger fractions of the horn. This means that over time, attractiveness of the horn will increase, which could influence incentives for poachers.

## Logistical challenges

Considering how incentives and disincentives influence a person's decision to poach suggests a critical mass of horn must be treated in a population to deter poachers. Theoretically, fractions larger than 50% introduce probabilities that a poacher more often than not will encounter rhinos with treated horns, disregarding publicity effects. A poacher will not be able to tell a treated horn from an untreated one on sight and will at best discover the status while removing the horn. Treated horns recovered from poachers showed that it is unlikely that a poacher will notice the pink drilling hole given that poached horns are often covered in mud and blood, and that poaching often happens in low light conditions to make escape easier. Poaching may continue until poachers find suitable horn. Ultimately though, more often than not, the chance of getting treated horn may be a large enough disincentive to overcome price incentives.

The number of rhinos living on an individual private property is usually small, making complete treatment of the population possible. Approximately 150 white rhinos on private property have been treated (Rhino Rescue Project 2013). Logistical requirements increase when the size of areas and populations increase. Recently, Sabi Sand Game Reserve treated about 15% of the white rhinos present, while Ezemvelo KZN treated approximately 65% of the rhinos in Ndumu Game Reserve and Tembe Elephant Park along the Mozambique border. Costs amount to USD 1,000 per rhino, inclusive of helicopter time and vehicles but excluding costs of drugs and veterinary expertise (Andrew Parker, pers. comm.[10]). The infusion procedure takes at least 30 minutes per rhino (Rhino Rescue Project 2013). Together with searching, immobilizing, treating, reversing, and preparing drugs and equipment, a team can expect 90 minutes to complete treatment of one rhino, allowing a maximum of four rhinos a day if the area is large and finding rhinos is difficult. In addition to such logistical requirements, a key challenge will be to identify and separate treated rhinos from untreated ones, extending the periods of operations in large areas and populations. Permanent marking of treated rhinos will be necessary. This poses additional challenges in that no permanent visible external markers are available. Most commonly used permanent markers are gum tattoos or microchip insertions, neither of which are visible in free-range wild animals. Invasive techniques like ear notching or tagging are the only alternative; they are effective in small populations but become difficult to impose on larger populations. Given these logistical challenges, the dye approach is feasible only in small and isolated populations.

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## Reduction of poaching

The conceptual challenges of chemically treating rhino horn, as highlighted earlier, predict variable effects on poaching rates. By 25 April 2013, infusionists have treated 230 rhinos with 4 of these subsequently poached (Rhino Rescue Project 2013). The poaching rate of treated rhinos of 1.74% (95% CI: 0.03–3.45%) is lower than the 2013 national poaching rate of 4.79% (95% CI: 0.23–9.37%), but confidence intervals overlap. In Sabi Sand Nature Reserve, we know of 3 rhinos with infused horns being killed since the inception of infusion during March 2013 and December 2013. During that period, we also know of 37 other rhinos killed in the same area (SANParks, unpublished data[11]), clearly challenging the deterrence value of horn treatment to poachers.

Before horns were infused, poachers killed nine rhinos in Ndumo Game Reserve and Tembe Elephant Park combined. Here, incursion rates also decreased dramatically, with 29 illegal entries by poachers recorded for the 3 months before the infusions, and 5 for the 3 months after treatment. Just before the infusions, however, law enforcers confronted and fatally shot an armed poacher and subsequently recovered a number of illegal weapons from the surrounding area. Sustained poaching pressure over the preceding months had also substantially reduced the number of rhinos present in both reserves and subsequently poaching pressure seemed to shift to other rhino populations farther south of the Mozambique border (personal observations). It is thus difficult to conclude that a chemical deterrent caused the reduction in poaching.

## Conclusion

Our assessment highlights key flaws in the assumptions that treating rhino horn will lead to decline in poaching incidents. We propose that human ethical and legal risks arise from assumptions for which we could not find any evidence. Consequences on animal welfare and health also carry large uncertainties.

Many of the above concerns emanate from the information base being primarily speculative. This was most evident when we assessed requirements associated with the procedure itself. Evidence indicates that at least one of the compounds in the most commonly used treatment is harmful to humans. Also, the structure and growth dynamics of rhino horn suggest that the efficiency of applying and maintaining the treatment may vary considerably. Claims by infusionists that the dye permeates the whole horn and is visible at the base of the horn when poachers remove it simply were not true.

To be successful, a critical number of rhinos need to be treated, with more demanding logistical requirements when areas and population sizes increase. This situation imposes several logistical challenges with potentially high costs to authorities.

These concerns highlight that authorities may carry substantial risks and have high uncertainty if they attempt to reduce poaching rates by infusing horns with chemicals as deterrents for end-users. This activity will detract authorities from achieving other conservation mandates. Relying on publicity to deter poachers also relies on managers being convinced that publicity on the chemical treatment of horns through infusion will secure rhinos. Poachers will benefit and managers will lose when the bluff of horn treatment fails. Chemical horn infusion is thus not a poaching deterrent but an ineffective deception.

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