RHINO RESCUE PROJECT – INFORMATION FOR CARTE BLANCHE

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An academic paper by the South African National Parks (SANParks) and Ezemvelo KwaZulu Natal Wildlife (EKZNW) titled "Are chemical rhino horn infusions a poaching deterrent or an unnecessary deception?" ("the Article") has been circulated prior to its anticipated publication in the Pachyderm Journal. Rhino Rescue Project (RRP) has as a result been approached for an interview.

At the outset we must emphasise that our primary concern is and has always been the welfare of rhinos in general and, of course, the animals we have treated. RRP is extremely concerned about the fact that treated rhinos could be targeted in the wake of any publicity casting doubt on the effectiveness of horn infusion – whether it be based on reasonable facts, or as we believe, not. As such, we have preferred not to take the debate to the media. Further, we are reluctant to comment on an academic document that has, to the best of our knowledge, not been officially published and of which the only copy we have was supplied by Carte Blanche.

We can, with the support of independent expert opinion, certainly provide a strong critique of the Article, which we have outlined below. RRP is concerned that the outdated information on which this Article is based, is being redistributed on a variety of public platforms as "new" – placing a target firmly on the back of every one of the 269 (out of 276) remaining animals treated by RRP to date.

Given the fact that this is now a "story" being covered, we value the opportunity to provide key points and more detailed information for Carte Blanche to consider.

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SECTION 1: SUMMARY OF KEY POINTS

RRP does not doubt the efficacy of horn treatments as a poaching deterrent. We will continue our research into developing near-perfect horn devaluation methods as we believe that this process is a valuable intervention to buy rhinos time in the war against poaching.

Horn devaluation by means of infusion has a multidimensional impact – not only the toxins and/or dye contributing to devaluation on a technical basis, but a powerful psychological and perceptual impact too. In fact, "a negative impact on health from consuming contaminated rhino horn" was one of the only two motivating factors mentioned by consumers in Viet Nam when asked what would convince them to stop using genuine rhino horn, as per the "Breaking the Brand" initiave.

In four years, only 7 losses of treated rhinos (due to poaching or natural mortality) have been reported to us, out of the 276 treated by RRP to date. Furthermore, based on feedback received from a number of randomly selected properties that formed part of a survey in 2013, horn treatments were regarded by over 90% of respondents as having been an effective poaching deterrent on their properties. The same number of respondents indicated that their animals did not appear to have undergone any negative changes in physical condition or behaviour after receiving horn treatments, and that the animals' horns appeared normal subsequent to the procedure(s).

When RRP rolled out treatments in 2010, we did so after carefully weighing our options: we could have waited until we had conducted extensive research on the methodology over a number of years during which we would continue to lose animals at an ever-increasing rate, or, provided that we were satisfied we would not be causing the animals any harm, based on Dr. van Niekerk's considerable experience in the field, we could launch the initiative, and work on refining the procedure on a continuous basis until we had developed it into a (near) perfect methodology. For the sake of our rhinos, we chose to do the latter. Retrospectively, this decision was certainly justified given the exponential rise in rhino poaching statistics beyond even the most pessimisitic predictions.

We have always been totally forthcoming about the experimental nature of our work, that all treatments form part of our ongoing research, and that horn devaluation is not a guarantee against poaching. We promise rhino owners the same level of transparency as we move forward with our research. With every treatment, we gather invaluable research data. We are

open to cooperation with any conservation bodies and welcome any data that can assist us in improving our methodologies.

We can further state with current scientific knowledge that horn treatments present no risks to the animals whatsoever, other than the normal risks associated with immobilization.

We would argue that the data gathered by the authors of the Article is incomplete for a scientific, peer-reviewed paper. We were denied any (meaningful) access to the research process, and have to date still not been furnished with promised samples that could have enabled us to do independent testing and take our work forward for the benefit of rhinos.

An independent review conducted by highly qualified chemist and forensic scientist, Dr. Hein Strauss, concluded that, as the Article is being forwarded as a scientific paper, one would expect some scientific evidence to corroborate the rather subjective judgement of a visual inspection by a person. He concluded that the visibility (or not) of the dye with the naked eye does not constitute the success (or not) of the infusion, and that it cannot be assumed that the transport behaviour of the ectoparasiticide through the horn would be the same (or even similar) to that of the dye.

We do not accept claims made in the Article that toxins could not have spread beyond the dye – of grave concern to us is the fact that the risk to consumers of ingesting contaminated rhino horn may now be greater, as the Article all but encourages them to ignore warnings about the potential presence of toxins.

To dismiss workable solutions based only on perceived shortcomings and limited data sets before RRP has concluded it's own data collection activities (at the end of 2014) is premature and does not in any way further rhino conservation efforts.

The authors would have been aware of the repercussions of damaging the reputation of an innovative anti-poaching measure which potentially threatens the legalised trade in rhino horn. Discussions unfairly discrediting any anti-poaching strategies without proper consultation should not be highlighted widely in public forums. The conservation fraternity owes it to the animals in its care to focus on shared goals instead of how best to fight those next to them in the trenches.

This one-sided critique of horn infusion appears to be driven by those with a pro-trade agenda. There is a much wider underlying story here which has the pro-trade vs. horn

devaluation debate at its core. We would draw your attention to the most recent article published in the Sunday Times on 20 July 2014, and to the subsequent request by the DA for the issues within SANParks to be investigated:

http://www.da.org.za/newsroom.htm?action=view-news-item&id=14138

There are those who are in support of legalised trade in rhino horn that perceive horn devaluation practices as a threat. We have been told directly by SANParks that 'poisoning' horns could tarnish the reputation of South African rhino horn in the minds of end consumers. Horns with a tainted reputation would not be marketable or could be preceived to be of a lower value, in which case nobody would be able to sell their horns if trade were legalised.

The pro-trade agenda is one that can only be raised with the next CITES CoP in 2016 - two years and many rhino carcasses away. In the interim, it is crucial for conservation agencies to embrace any interventions that can keep a flagship species like rhinos from the brink of extinction.

Some economists promote the concept of "flooding the market" by which they believe that supplying end-user markets with stockpiled horns will drive horn prices down and reduce poaching. This naive thinking pattern indicates to us that they do not understand the buyers of rhino horn and their motives. It is after all an illegal market, and thus doing market research becomes virtually impossible. With so many unknowns, and so few live rhinos left, we believe the most prudent course of action is to reduce the demand, rather than attempting to supply (and feed) it. This approach is consistent with the globally-accepted litmus test for national environmental decisions, the so-called “Precautionary Principle”. This tenet is applicable where, due to unavailable scientific knowledge, there is uncertainty as to the future impact of a proposed development.

If we can encourage end-users to stop buying rhino horn, through a combination of horn devaluation (short term) and consumer education (long term), the killing of these iconic animals can hopefully stop too. Such social marketing campaigns have only been implemented in Viet Nam recently, with the first messages specifically targeting end-users being distributed in 2013.

http://blogs.wsj.com/searealtime/2013/09/16/rhino-horns-can-make-you-sick-vietnamese-moms-to-be-warned/

Dr. Lynn Johnson, founder of the “Breaking the Brand” project in Viet Nam, finds the timing and motivation of the Article interesting, and questions whether this issue is about protecting rhinos or protecting rhino horn value for a future legal trade.

A real poaching solution will include the application of multiple interventions and we need to embrace any creative solutions that may indeed help, although there may be a need to research, refine and improve such protocols. We must think out-of-the box to find solutions to an out-of-control problem.

It was always our hope that a research-collaboration between RRP, SANParks and EKZNW made possible with a portion of the funding obtained from the Dutch National Postcode Lottery by the Peace Parks Foundation (PPF) would enable the refinement of a truly robust devaluation technique that would satisfy all the concerns raised by the sceptics and continue to keep rhinos alive.

SECTION 2: OVERVIEW AND BACKGROUND TO THE ARTICLE

Dr. Sam Ferreira and three other colleagues, from SANParks (Markus Hofmeyr and Danie Pienaar) and EKZNW (Dave Cooper), have recently categorically rejected the merits of horn devaluation in the form of infusion as an anti-poaching measure in a (as yet unpublished) research article titled “Are chemical rhino horn infusions a poaching deterrent or an unnecessary deception?”

The authors base their conclusions on a number of factors, including alleged conceptual, ethical - and legal issues. Further, the technical efficacy of the procedure is critiqued, based on anomalies observed during the visual inspection of horns recovered from a suspected poacher inside the KNP approximately 11 months ago. In excerpts from the Article leaked to the press prior to its official publication in the Pachyderm Journal, the authors allege that these horns originated from an animal treated by RRP in the Sabi Sands Wildtuin (SSW) after which it reportedly traversed what can only be described as an inordinate distance into the Kruger national Park (KNP), where it was subsequently poached.

On being made aware of the existence of the KNP horn(s) and their apparent infusion "anomalies" on 27 August 2013, RRP immediately contacted all properties on which we had previously performed treatments as well as properties that had treatments lined up to inform them of the discovery and to give them the option of postponing their procedures until such time as our investigation into the occurrence had been completed.

This included EKZNW and PPF. EKZNW, although fully aware of the latest developments, made a conscious and informed decision to pursue the hugely successful pilot project undertaken in Ndumo Game Reserve and Tembe Elephant Park during the latter part of 2013 (using donor funding from PPF originally intended for the KNP, but declined by them). This research opportunity has already enabled us to introduce significant improvements to our procedure and modifications to our treatment compounds – with yet more to come. As we communicated the latest developments to relevant stakeholders as soon as we became aware of them (via email on 3 September 2013 and also via an update to same on 22 September 2013) we did not believe it was necessary to distribute the information publicly when our own investigations had not yet been concluded. At the time we could not have anticipated that the samples promised by the KNP, which would have allowed our own analysis into the reported inconsistencies (as far as possible without the actual horns), would not be forthcoming to date.

It is no secret that SANParks is opposed to the concept of horn devaluation. In fact, during a meeting at Skukuza in June 2013 (two months prior to the “discovery” of treated horns in the KNP) at which two of the authors of the Article were present, it was made clear to both RRP and PPF that the KNP was *not* interested in implementing a fully funded pilot project to actually *test* the efficacy of horn devaluation in poaching "hotspots" on the Eastern boundary. A number of reasons for this decision were communicated to us:

- The KNP was of the opinion that the poaching problem was, in fact, not the “crisis” many perceive it to be when rhino meta-population dynamics are considered.
- Further, concern was expressed about the effect of horn devaluation on the “secondary economy” (from rhino poaching) that had mushroomed on the KNP/Mozambique border.
- Lastly, the KNP has a sizeable stockpile of horns that it would never be able to sell if the "reputation" of SA horn is tainted in the mind of buyer markets.

See:
http://www.iol.co.za/scitech/science/environment/sa-s-new-push-for-sale-of-rhino-horn-1.1712529#.U7QeIhYlYqc

In light of these revelations, the discovery by the KNP (described by one of the co-authors of this Article as “fortuitous”) of a treated horn at a time when it was under significant pressure from the Department of Environmental Affairs (DEA) and others to allow the above-mentioned pilot project to go ahead, must be questioned.

Nonetheless, whatever the origins of these horns, we considered their analysis a valuable research opportunity, as the National Environmental Management: Biodiversity Act 100 of 2004 (NEMBA) and existing TOPS legislation does not typically make provision for rhino horns to be dissected for research purposes. We have, during the past three years, had great difficulty in obtaining permits to take our own physical research forward. We can only assume that the KNP enjoys special dispensation, although we can find no evidence of this in the National Parks Act 57 of 1976.

As previously mentioned, RRP requested permission from the KNP to examine the dissected horn(s) and take samples of the horn material for, amongst others, DNA – and toxicology testing. To date, almost a year later, and despite formal commitments to do so, we have not yet been furnished with any samples or research outcomes / data sets. We were also not able to get a copy of the Article from the contributors themselves or their employers.

Dr. Dave Cooper (EKZNW) denied being a co-author to this paper, and SANParks denied the very existence of the paper as recently as 20 May 2014 (telephone interview - William Mabasa, HOD: Public Relations and Communication, Kruger National Park).

After the so-called “discovery” in August 2013, Dr. Mike Knight of SANParks/IUCN distributed a preliminary report on the initial findings by Dr. Markus Hofmeyr, to a very comprehensive mailing list of recipients, but did not include RRP. There is some concern that the bias demonstrated by Knight and SANParks against horn devaluation in these initial email threads taints the acceptance, peer review and publication of the current paper in the Pachyderm Journal, as Knight is also on the editorial board of the publication, and is the chair of the IUCN Rhino Specialist Group to whom any letters of complaint with respect to Pachyderm Journal publications are to be addressed.

As with all experimental technologies, the infusion process (and other forms of horn devaluation) continues to evolve significantly and rapidly. However, since the sole referenced source of information the authors of the Article consulted on the procedure appears to be the RRP website (in a single web browsing session 15 months ago) it is unlikely that they would have been aware of any of the most recent developments – an oversight the peer review process should have exposed.

Unfortunately, it would appear that, although the Article makes crucial concessions in terms of the potential for success of infusions on smaller properties and amongst relatively small rhino populations, and the discussion surrounding technical efficacy is but one section of the upcoming paper, it has been the angle most detractors have chosen to focus on almost exclusively – undoubtedly to the detriment of treated rhinos everywhere.

http://www.witness.co.za/index.php?showcontent&global%5B_id%5D=118884

Even without the benefit of any of the information set out in this document to place the Article in context, one journalist, at least, seems to have seen through the “issues” and got it right for rhinos:

http://www.witness.co.za/index.php?showcontent&global%5B_id%5D=120414

Had we known the scientists in question were working on a "study" of our work, we would have liked to share our own latest data with them. We were, however, never formally

approached for our comments or inputs by SANParks/EKZNW or their representatives. None of our requests for research outputs or data collected have been met. It was our hope that RRP and SANParks could have worked together to do any required research to ensure that the treatments were effective on all levels, rather than to dismiss them. With our work, we could have given the KNP a three year head start with any horn devaluation research they may have wanted to continue with.

Law enforcement, of course, remains crucial in the war against poaching. However, law enforcement efforts are sufficient only to limit the rate of loss, so what other possible solutions exist? Certainly, education and demand reduction campaigns in consumer markets represent an absolutely essential long-term strategy but with only 25,000 rhino left in Africa and losses to poaching currently exceeding 1000 per year, there is simply not enough time for these efforts to save the rhino from extinction. By devaluaing the asset, the risk/reward ratio for criminals is altered. Increased investment into law enforcement increases the risk and devaluing the asset reduces the reward. If pursued simultaneously, the risk/reward ratio becomes increasingly unfavourable for the criminal.

Horn devaluation as a concept is a highly successful and effective anti-poaching measure. We have proof of this. There are numerous ways to devalue horns; infusion was the technique we started with because we had to start *somewhere*. We have consistently said that treatment is *not* a substitute for other security measures, but a supplement to them.

As much as many others believe that legalised trade will make the most meaningful difference of all possible interventions, it is still two years and many rhino carcasses away and is by no means a “fait accompli”. In the interim we, for one, stand for doing everything we can to try and save as many rhino as we can.

Economics

The solution to the poaching crisis will almost certainly be an economic one. For as long as rhino horn has cultural value, the demand for it will persist. For as long as demand persists, rhino horn will have economic value. Therefore, in reality, only two economic options exist. We either need to combat demand by removing the value of the commodity or we need to legitimise the value of the commodity so that the returns are not captured solely by criminals. The question of legalising international trade in rhino horn as a mechanism to legitimise the value of the commodity is a highly contentious one that, even if approved, will be subject to a lengthy lead time due to the CITES process. This therefore leaves the elimination of the

value of the commodity as the only economic option in the interim.

The horn contamination procedure developed by RRP represented the first attempt to eliminate the value of rhino horn as a commodity. Thus, when defining "success", it is imperative to differentiate between technical issues versus the thinking behind devaluation of rhino horn. Every pioneering technology has teething problems and if there are problems with the *procedure* but merit in the *concept*, it remains imperative for the conservation community to persevere until an effective procedure emerges. Instead of criticism, pioneers should be encouraged to continue researching the development of more effective procedures so that devaluation of rhino horn can contribute meaningfully to saving as many rhino as possible in the immediate term while policy makers and politicians continue to deliberate on the trade issue.

http://www.iol.co.za/scitech/science/environment/rhino-horn-trade-panel-why-the-silence-1.1717753
http://www.conservationfinder.com/rhinos-lose-out-in-kruger-turmoil/

The misconception exists that legalised trade in animal parts is the *only* strategy that can save the species, to the exclusion of all others, even if it failed in driving down poaching under elephants, tigers, bears and the saiga antelope (whose horns – based on their internal structure – are considered the closest substitute products to rhino horn available at present, with horse hooves a close second.) Further, no thought appears to have been given to the fact that legalised trade in horns will set a dangerous precedent for all other (endangered) wildlife in South Africa.

Legalised rhino horn trade is too far away to save our rhinos. According to latest reports, 3 rhinos will die from poaching today (http://oxpeckers.org/2014/05/kruger-rhino-kill-rate-up-to-3-a-day/) another three tomorrow and another three the day after that, and three more *every* day until legalised trade can even be *proposed* to CITES in 2016. That is 2190 animals. Then we face another stumbling block: 2/3 of CITES member countries would have to vote in favour of the legalised trade in animal parts before any kind of agreement could be reached, and it is highly unlikely that this will happen in 2016. Even if an agreement is reached then, ironing out the logistics involved in creating a Centralised Selling Organisation (CSO), for example, would require an additional four years minimum, during which another three animals will be lost every day for 1460 consecutive days. Rhinos are slow breeders, with an annual growth rate of only 5% – 6% (optimistically). Have conservationists become so consumed with “winning” this argument that they cannot grasp what will happen long

before CITES 2016? By then, the permanent downward curve towards extinction would have begun and the decision to trade in rhino horn as a possible solution will be moot.

SECTION 3: CRITIQUE OF THE ARTICLE

The Article itself contains a number of factual inaccuracies and very little scientific analysis at all. Several disparaging statements are made based on little more than cursory visual inspections, supposition and outdated literature. More recent and relevant sources were available and should have been consulted. In academic literature, websites are commonly considered the least reliable sources of information. If consultation with primary sources is at all possible, this is deemed a far more reliable means of obtaining information. The Article's list of references that relies heavily on web searches (Rhino Rescue Project's web site was cited as the sole source of information on the project, based on a browsing session from April 2013), prior articles or papers written by the authors themselves and literature that is largely unrelated to rhinos (i.e. Bonier, Quigley and Austad's on cougars and Carlstead, Brown and Seidensticker's on leopard cats).

Unlike virtually all other peer-reviewed papers, this Article contains no section addressing the limitations of the study and no suggestions for future research. At least, if a potentially viable anti-poaching measure was going to be dismissed out of hand, it would have been reasonable to expect that other alternatives may be recommended in its stead. The criticisms expressed in this Article seem to imply that not only are South African rhino owners obliged to supply criminal/poaching syndicates and the buyers of illegal rhino horn with a good-quality product that has not been tampered with, but they are also expected to make available any and all details relating to their anti-poaching strategies (especially possible flaws) to the public (and thus, the syndicates) even if these disclosures are counterintuitive in an environmental war and could be to the detriment of the animals in their care.

It is in the light of these issues that a number of key statements from the Article are dealt with in what follows. Extracts from the Article are set out in red italics and consecutively numbered.

Abstract

1. *"We visually examined white rhino horn that had been treated, examined available literature and obtained expert opinion to assess several assumptions and risks associated with the approach."*

In addition to comments based on a macroscopic inspection of the horns, the Article ventures certain “implications”. These are damning of all such treatments that have been performed on rhino horns. Despite the position of RRP as an interested party and one likely to have information pertinent to these “implications”, no opportunity to comment on or contribute to the views expressed was afforded to us at any stage during this “research”. Whereas positive feedback could have been obtained, an election to proceed instead based on pure assumption has been adopted.

A very limited number of “experts” were consulted in writing certain sections of this Article and in other sections no experts were consulted at all. Instead the authors’ venture opinions or cite their own prior works as the sole sources of information.

Moreover, the question of what is a suitably qualified “expert” to make the appropriate analysis and draw conclusions from the data available seems to have been something dismissed or overlooked. Definite conclusions are nonetheless drawn based on indefinite tests and supposition. This is a highly unscientific way to approach writing a “scientific” paper, particularly in the light of previous comments regarding available information and the fact that the matter is one that may lead to targeting of treated rhino. Some of these alternative sources will be pointed out in the remainder of this document.

The Article was completed and circulated without the courtesy of RRP being copied in on the correspondence or receiving any notice from the authors.

Introduction

2. *“The international call for intensified protection of rhinos through traditional anti-poaching measures may fail to curb illegal killing because the disincentives created do not outweigh the incentives of financial benefits (see Ferreira et al. 2014).”*

The referenced source of this statement is another recent paper by at least one of the authors of the Article. This second work is titled “Management strategies to curb rhino poaching - alternative opinions using a cost-benefit approach”. Of this paper, Dr. Lynn Johnson of Breaking the Brand says: *“The strategy being used by a small number of South Africans to undermine any anti-poaching technique that can also weaken demand is an embarrassment to their fellow countrymen. The papers emerging at the moment certainly*

prove that these people have no idea of the scale of Asian marketplace for rhino horn."

Similarly, journalist Don Pinnock expressed this opinion*: "It may be in a scientific journal, but has nothing to do with hard science. It's merely an exercise in getting 30 mostly like-minded people in a room and tabulating their suggestions about rhino trading with complex mathematical formulae. Clearly the workshop contained few of the people opposed to trading in horn."*

The following link to an Pinnock's article which references the work of two top economic analysts in this field is relevant:

http://www.dailymaverick.co.za/article/2014-06-17-op-ed-egg-dancing-on-a-bloodied-horn/

3. *"Typically, horn treatment is an infusion of a compound or combinations of compounds into the horn of a live rhino. The most common infusion comprises an indelible dye and deposit of ectoparasiticides (Rhino Rescue Project 2013). The effectiveness of horn treatment as an added disincentive for rhino poaching is unknown."*

If the effectiveness of horn treatment as a disincentive is "unknown", how can it be condemned as "ineffective" or labelled a "deception"? Horn devaluation can take many forms of which infusion is but one. Although it is almost certainly not the most effective way of devaluing horns completely, it was a minimally invasive starting point in RRP's research into horn devaluation, in the absence of existing methodologies or relevant accessible literature.

As previously mentioned, in the 11 months since the "discovery" of "treated" horns in the KNP, changes have been made to the infusion procedures and there has also been progress with alternative devaluation techniques – a fact of which the authors of this Article would have been aware had they not deliberately concealed their "research" from RRP. We must emphasise, as we have before, that the procedure developed by RRP remains a work in progress. We constantly identify and work on resolving certain problems as we become aware of them.

Infusion was a critical starting point towards developing a "perfect" devaluation methodology. We maintain that the treatment is not a substitute for other security measures but, rather, a supplement to them. It is not a silver bullet, but it is another arrow in the quiver against poaching. Regardless of any technical issues associated with the procedure, and despite

efforts to discredit the practice in its entirety, the concept of devaluation remains pivotal in the fight against poaching. Similarly, rangers in the field are an absolutely critical component in this fight – but expecting those on the frontline to solve the problem is akin to expecting a paramedic to perform open heart surgery on a cardiac-arrest patient at the scene of the heart attack. Like the paramedic, the job of the ranger in the field is to secure enough time for the root cause of the problem to be identified and remedied.

The results of our (as yet unpublished) research into the efficacy of horn treatments as a deterrent to poachers conducted during May/June 2013 were made available to the authors of this Article on at least one occasion (on 25 July 2013 at Skukuza). Their assessment that the effectiveness of infusion as a disincentive for rhino poaching is "unknown" is therefore unfounded. On the majority of properties where they were performed, these procedures were indeed considered effective in curbing poaching – a fact of which the authors were aware, but elected not include in the Article.

4. *"Reduction in poaching rates, however, is the ultimate success measure…"* and *"…to date, infusionists treated 230 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%)…"* (from the section headed "Reduction of poaching")

By the authors' own admission, a reduction in poaching rates is *"the ultimate success measure"* of any anti-poaching method. By this standard, the above figures support the argument that rhino horn infusion is indeed an effective deterrent to poachers, in that the poaching rate of treated rhinos (1.74%) is significantly lower than the national poaching rate (4.79%). Even when these figures are extrapolated (i.e. applied to a total population of 21000 animals, as per the above calculations by the authors) the rate of poaching amongst treated animals still only amounts to 2.53% i.e. 2.26% less than that of untreated animals.

These figures can be represented even more simply: out of the 1004 animals lost to poaching in South Africa during 2013 (of which 606 were poached in the KNP) only 4 were previously treated by RRP. Out of a total of 276 animals treated by RRP over a four year period, only 7 animals have been reported lost to poaching or natural mortality in this time. This means that, on average, less than 2 treated animals have been lost *per year*, whilst almost 3000 rhino have been lost countrywide to poaching since 2010.

Conceptual challenges

5. *"A key challenge arises, however, because infusionists create two rhino horn commodities – treated and untreated horn."*

The same scenario would exist if trade were legalised: "farmed" rhino horn is often considered (in end-user markets) to be an "inferior" substitute for "wild", previously unharvested rhino horn. This strategy failed to impress end-users into purchasing farmed bear bile; most still opted for the bile obtained from wild, free-roaming animals. The sale of accumulated "dry" rhino horn from stockpiles (most of which is, incidentally, also treated with pesticides for purposes of storage) would create a third commodity.

6. *"Increasing supply of treated horn (or horn perceived to be treated), assumed to have no value and thus demand, reduces the supply of untreated horn (whether real or perceived), causing a growth in demand."* and *"Outcomes for small reserves disregarding wider implications may thus actually stimulate poaching in other areas."* and *"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."*

The essence of the economic argument made by the authors is that devaluing horn through infusion does not in itself reduce demand for untreated horn, so it will only drive poachers to seek out untreated horn from somewhere else. This may be largely correct, although it ignores the fact that simplistic economic modeling does not apply in markets where organised crime is present (Fischer, 2004) nor do traditional laws of supply and demand apply for commodities where supply is independent of demand. It is, furthermore, deceptive for two reasons:

a. The argument used by Ferreira et al. applies in the same way to other protection measures such as armed rangers, tracking dogs, drones, camera traps etc. One could argue that these measures simply drive poachers to seek out less protected parks and reserves. Where is the difference? Given this, why are the authors singling out horn devaluation vs. other anti-poaching measures? The apparent difference is that protection/security based anti-poaching methods will not adversely affect the value of

the horn in a future, legalised market place but horn infusion/devaluation treatments have the ability to do so.

b. The true value of horn infusion and other possible forms of devaluation is that they are the only measure that can impact end user demand. Criminal elements in the supply chain may find ways to wash out the dyes from devalued horns (although no evidence of this exists) but can they be sure they can get rid of the toxins? Hence end users may start to get sick and fear and doubt about the safety of the product will enter their minds. Health concerns are the primary reason end users have voiced when asked specifically what would stop them consuming genuine rhino horn.

All current measures put in place are designed to deter or reduce poaching (protection measures or devaluation of horns). This means they reduce supply and thereby increase the price of untreated horn. As these measures are embraced by more and more parks, reserves and conservancies, the supply chain will get more desperate and step up its attempts to secure precious, untreated horn. The only viable solution to this continued escalation is to reduce end-user demand. The Breaking the Brand project is proposing to do exactly that. Knowing the motivations of end-users means that infusing toxins is a great strategy to foster health fears in the end-user group.

Legal trade in horn can only become a viable solution once the current demand spike has been deflated. There is too much pent-up demand in Viet Nam and TRAFFIC estimate that 90%+ of rhino horn sold in Viet Nam is fake. The current users of genuine rhino horn further have no interest in horn from farmed animals or from stockpiles (treated with pesticides to prevent horn mites). This means legalisation of trade at this point in time is going to be counter-productive. It will only increase the market size but not reduce poaching of wild rhinos (Breaking the Brand, 2014).

It is not apparent how the authors of this Article are qualified to introduce and rely on these complex economic arguments.

Legal and ethical challenges

7. *"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."*

RRP understands that the authors of the Article are aware of, and were supplied with, a further legal opinion (provided as two memorandums) drafted by counsel briefed on behalf the Peace Parks Foundation (PPF) in June 2013. The opinion in question was not limited to the *Par Delictum Rule*. It is not apparent how or why this information was omitted from the Article.

8. *"The end-consumers will 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."*

Rhino horn cannot be purchased "legally" as traditional medicine or otherwise in any of the primary end-user countries. Any end-consumers wishing to initiate and give evidence in legal proceedings could potentially make a great contribution in exposing entire criminal supply chains, as the horn would have to be tracked back to its point of origin to prove that the treatment had taken place and had resulted in the "plaintiff" suffering adverse health effects.

It is not apparent how Ferreira et al. are qualified to draw any conclusions or express such views relating to legal matters.

9. *"Cultural rights dilemmas may also be associated with horn infusions. Key stakeholders within the countries with the highest 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 the Parties (Cooney and Abensperg-Traun 2013)."*

This statement, as RRP interprets it, seems to imply that South Africans should indulge foreign cultural customs (that fuel the illegal trade) with "clean" rhino horn for poachers at the expense of this flagship species (to be protected as part of our heritage) that is approaching extinction so as not cause some (chance of a possible) diplomatic incident/offense in end-user countries. We do not expect that the authors will find any echo of support for such a proposal from the local community.

The "ethical" attack on horn devaluation from these representatives of SANParks/EKZNW

should be considered in the light of SANParks/EKZNW, apparently, having no ethical reservations to selling (in the future) a bogus medicinal product at hugely inflated prices or at least stockpiling an illegal one for that purpose. See the following links:

http://www.ecr.co.za/post/opinion-bandile-mkhize-on-rhino-horn-trade/ and http://conservationaction.co.za/recent-articles/regardless-of-resistance-sa-will-still-trade-horns/?utm_source=rss&utm_medium=rss&utm_campaign=regardless-of-resistance-sa-will-still-trade-horns

It could be argued that the recent press surrounding the desire of the South African Government (of which SANParks and EKZNW are but extensions) to trade in rhino horn legally provides an indication as to possible driving forces behind articles of this nature, aimed purely at eliminating any perceived threats to legalised trade, rather than saving the lives of rhinos or adding to the (very limited) body of academic literature currently available on rhinos.

10. *"We could find no formal evidence of behavioural assessment of either pre-treatment vs post treatment, or control vs experimental comparisons."*

Not all research is performed for the sole purpose of writing articles. Occasionally, researchers in the field do research in order to measure progress and adjust procedures accordingly. In this way, RRP embarked on a survey under our existing customers in 2013. We randomly selected a number of properties on which horn treatments had been performed at least 3 months prior to the start of the survey. Rhino owners were asked to assess the success of the horn treatments on their properties based on three research questions: (1) Had there been a significant reduction in incursions/poaching on the property since horn devaluation procedures had been performed; (2) Were the treated animals in worse/similar/better physical condition after treatments; and (3) Did the treated animals' horns appear to have been affected in any way by the treatment.

The research findings (albeit unpublished data) were extremely valuable, and overwhelmingly positive. The authors of this Article were fully informed of this survey and its results.

Essentially, everything that is being done by RRP is pioneering work. Waiting for plethora of trial results addressing the multiple facets of a process of this complexity will take many

years. While the "perfect" scientific results are being compiled, rhino numbers would continue to plummet towards extinction. These were the considerations which "forced" a decision to proceed with "learning by doing" – as long as we could be sure that we are not doing more harm than good for rhinos.

Data that is available with regard to the infusion compounds was used and extrapolated as is the case with all medication in wildlife medicine (with the exception of dedicated immobilisation drugs that we use).

11. *"An immediate health risk to the rhino is associated with immobilization of the individuals, with the anaesthesia procedures resulting in at least one white rhino dying during the horn infusion process (Beeld 2012)."*

Two rhinos lost out of 276 procedures amounts to less than 0.73% - a number far under what are considered "acceptable" losses due to immobilisation. The risk of immobilisation is the same regardless of the management procedure being implemented. RRP is acutely aware of this and as a result has made a concerted effort to maximise the opportunity of "getting hands on" the rhino. DNA samples, micro-chipping, ear notching, pregnancy testing etc. are done at the same time to optimise the benefit gained from a single immobilisation. RRP has also implemented additional steps during the immobilisation to further reduce this risk. These include oxygen supplementation and specific anaesthetic regimes (precautions implemented by RRP without the support of published data). Treatments of "classes" of animals where the risk (however small) is higher are avoided (cows with small calves, young calves and very old animals). The same cautioned approach has not been demonstrated by veterinarians at some state owned reserves. We would be interested in comparing this figure (0.73%) from our procedures to those which go unreported in the state owned parks.

In our opinion, the relatively small risk of immobilisation against the benefits of all of the value-added elements that form part of the total treatment "package" is mitigated when compared to the current rate of poaching (in excess of 3 reported losses per day).

12. *"Experience of immobilizing rhinos to notch, translocate or treat injuries suggests that the typical 30 minutes to complete the process (Rhino Rescue Project 2013) would be considered long (personal observations). In addition, this does not include effects of chasing rhino during the actual darting operation. At least one study illustrated that rhino immobilizations 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 following capture (SANParks, unpublished data2).”

It is not apparent how “non-adaption” in a boma environment has anything to do with RRP treatments. There are a number of procedures currently performed on rhinos that require far longer immobilisation times. For example, the fitment of a GPS tracking device typically takes between 50 minutes to 90 minutes to complete. Despite this, these procedures are frequently performed without, to the best of our knowledge, the publication of scientific articles denouncing their use on this basis. Routine translocation procedures can also take much longer. Indeed, there are many examples of logistical, mechanical and environmental difficulties which can prolong immobilisations to an hour or more, but are considered a normal part of the industry. These eventualities almost certainly occur in the KNP too, despite a veterinarian’s best efforts to avoid unnecessary delays in reversing the immobilisation drugs. Darting and treatment stress would be no more for horn treatment than for any other operation. In fact, it would probably be less than for translocation because the rhino does not have to be moved to an area suitable for access by recovery trucks, for example. The RRP team is mobile and gets to the immobilised rhino for the treatment.

13. *“Multiple captures of rhinos, particularly young rhinos, may carry chronic stress consequences given requirements of re-treatment every 3-4 years (Rhino Rescue Project 2013).”*

RRP has no knowledge of any work that has focused on this and, thus, on what basis the statement regarding “chronic stress” is made. This, we submit, amounts to pure conjecture. Given that dehorning procedures, for example, need to be repeated once every 12 to 18 months in order for them to remain reasonable deterrents to poachers, horn devaluation procedures are actually a safer alternative from a “multiple capture” perspective. The absolute minimum number of interventions is first prize. As we have always advocated devaluation is a temporary “desperate” measure taken in “desperate times”. In the private sector a large number of young rhino are immobilised multiple times in a short space of time, for management and translocation procedures. The actual statistics are not available, but it is estimated that the average rhino in the private sector gets immobilised more than once every 3-4 years.

14. *"Horn infusionists reported anecdotally no detrimental effects on rhino health following capture for treatments (Rhino Rescue Project 2013), but no formal evidence is available."*

To date, no formal evidence of this nature has been requested. It is highly unlikely that the health of rhinos after capture for the purposes of infusion would be markedly different to that of rhinos captured for any other reason – whether it be dehorning or translocation. Yet, as has been mentioned before, with the exception of horn infusions, none of the other procedures appear to be deemed particularly controversial by SANParks/EKZNW. It should also be noted that none of the other alternatives potentially threaten the legalised trade of rhino horns in future, which may or may not be linked to the different sets of criteria by which each method has been "evaluated". With RRP's relatively limited resources and access to research material due to legal and/or bureaucratic obstacles, we use every opportunity offered to us to collect relevant field data. Unfortunately, it has become apparent with the publication of this Article that we have been actively excluded when data sets from our work have become available and denied an opportunity to use these data sets to further our own research.

15. *"A key concern is contamination of growth tissue at the base of the horn. As the procedure uses high pressure [sic] systems to force chemicals into hard horn, the infusion of soft tissue should be simpler and may result in mechanical damage. We could find no literature on the effect on growing tissue at the base of the horn.*

As already mentioned, everything that is being done by RRP is pioneering work to save rhinos from becoming poaching statistics under circumstances where we are certain that we are not doing more harm than good.

16. *Neither could we find literature that described health benefits from infusion techniques for ectoparasiticide treatment, although topical application of medication has been used for wound treatments on hooves, for which effectiveness of such treatment is still debated in the veterinary field (Johan Marais, personal communications3)."*

There was some initial research into the possible use of rhino horns as depots for ectoparasiticides in order to control parasites on animals in captive populations (especially in areas where tick loads, for example, are extreme). As previously mentioned, known data that is readily available with regard to the infusion compounds was used and extrapolated, as is the case with all medication used in wildlife medicine (with the exception of dedicated immolilisation drugs).

However, with the sudden increase in poaching from 2009 onwards and with "devaluation" in mind as a possible deterrent, we worked the idea of using an ectoparasiticide into the treatment methodology which has developed into the anti-poaching measure it is now, in combination with microchipping, DNA sampling and tracking technology.

17. *Such an evaluation should include consequences of disrupting parasite-host interactions of rhinos. We could find no evidence of such evaluation prior to and after the commercial launching of the infusion product."*

Our work in EKZNW was to form an integral part of this evaluation. Once again the lack of available knowledge/data was a drawback in that "normal values" or research "baselines" have to be established first, for any subsequent test results to be compared to. This kind of trial to get significant data (as the authors would know) is influenced by multiple factors and to establish even "normal values" could take several years. Do we have time to wait for these definitive works before attempting to save rhinos lives? We have always been clear about the fact that, from a research perspective, we were forced to roll out treatments sooner than we would have liked because there was such a great demand for them. We felt comfortable with this decision, as we realised that, at worst, it may have no deterrent effect at all, but at best, we could potentially save animals' lives, without exposing them to undue risk in order to do so. At present, the risk of an animal getting poached is exponentially higher than any risks imposed by this procedure.

A number of approaches for "commercialisation" of the process have been turned down by RRP, primarily because we had not reached the end of our research phase of the project. Had we been particularly "commercial" in our orientation, we would most certainly have capitalised on these opportunities instead of erring on the side of caution as we did. Similarly, as a service provider to rhino owners instead of yet another rhino "charity", soliciting donor funding has never been a priority for RRP. Given that there are more than

enough individuals and/or corporations willing and able to donate to this cause, we could actively have pursued this had our motives been more “money minded”.

Science challenges

Before dealing with this section, we state for the record that our comments have been limited by what we can observe in photographs of the dissected horns that are referred to in the Article. This was not enabled through any cooperation on the part of the authors.

We deal below with this section of the Article relying on the information that is available under circumstances which, we submit, amount to a premature and biased attack on horn devaluations based on an inconclusive analysis of material to which RRP access has been denied.

18. *“Conservationists stri[v]e 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.”*

Some of the “scientific assumptions” that are made by the authors warrant evaluation. It also appears that the paper does not (really) enable any “robust science-based decisions”.

Chemical deterrence potential

19. *“The exact ectoparasiticide combinations are unknown, with no defined human health risks. Most commercially available ectoparasiticide products are relativity safe to humans and unlikely to have any serious health consequences in the quantities ingested from known rhino horn products (Johan Marais 5 and Gerhard Steenkamp 6, personal communication).”*

Ectoparasiticide products generally carry warnings against ingestion on either or both of the packaging and package inserts. These clearly marked “poison labels” (“not for human consumption”, “harmful if swallowed” etc.) usually include instructions to immediately consult a doctor if accidently ingested. Registration conditions are imposed after many years of clinical trials by the registration holder. It is not apparent on what basis this is now being dismissed.

20. *"Drugs used to treat animals followed by subsequent consumption of meat with residual hormonal and medical drug residues resulted in a small percentage of persons affected (Board of Agriculture 1999). It is unlikely that end-users will notice an acute effect, because rhino horn for medicinal purposes comprises small doses mixed with other substances."*

The consumption of meat (protein) has well established benefits (as opposed to being based on a myth). Any associated intake of "chemicals" resulting from the treatment of the livestock is considered undesirable. There is a sizeable body of literature on the negative effects of hormones, antibiotics etc. in meat from domestic animals (as opposed to preferred options of such as "free range" or "grass/grain fed"). The literature suggests, amongst others, at high incidence of cancer. The comparison or attempt to draw parallels between the "considerations" of consumers of illegal rhino horn based on its mythical properties and those of consumers who live on a diet that includes meat probably warrants further criticism (and if anything reinforces the notion that consumers do not like contaminants) but it is, we submit, an "analogy" that needs only to be stated in order to be dismissed as irrelevant.

21. *"In addition, it is an assumption that people will 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 contains 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)."*

If prepared correctly, which is invariably the intention, the naturally occurring toxicity of the puffer fish is removed. The toxicity does not arise as a result of a deterrent, devaluation treatment aimed at dissuading illegal consumption. Nobody wants to knowingly consume tuna fish with mercury contamination (even if sudden symptoms would not manifest).

Application efficiency

22. *"Rhino horn is essentially papillary cornified epidermis (Hieronymus et al. 2006) and 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 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 (Fig. 1). Most importantly, the variations in melanin content and calcification result in differential wear, the key mechanism for horn shape (Hieronymus et al. 2006).

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."*

23. *"We could find no literature assessing the efficiency of this procedure in distributing chemical compounds evenly through the cornified epidermal tissue of horn."*

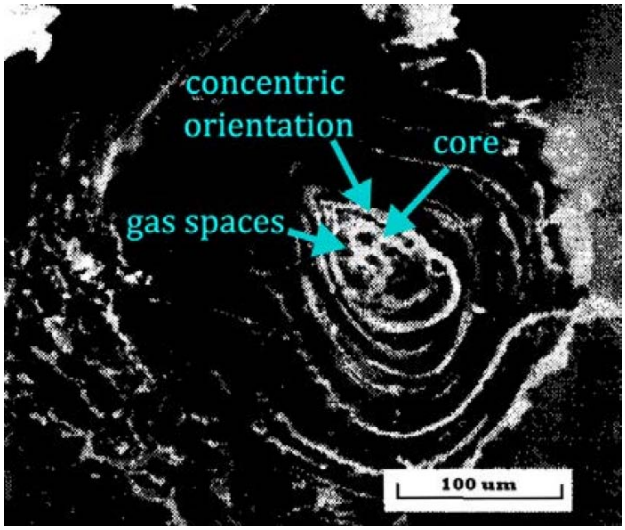
The authors' rely on an absence of research data. The KNP/SANParks is the one institution from which horn devaluation could really have (aside from RRP's efforts) benefitted and evolved over the last few years. They have had the means (stockpiled horn) and the permissions (we assume some legal dispensation or the required paperwork) to run tests on and cut rhino horn as they see fit - we have not. Instead of furthering this counter poaching

strategy in a proactive productive manner (and even if it had been done for the benefit only of private rhino owners, with limited means to implement other measures), nothing was done, apart from producing the current Article aimed at eliminating horn devaluation. The "views" of the authors are offered in reaction to the loss of treated rhinos and these losses, in turn, are now being used to support those "views".

There is (arguably) a degree of embarrassment that should accompany such a reliance made in support of the findings of a "scientific" paper on the topic of rhino horns when you (the authors) are at the forefront of conservation in the country which represents the most significant population of an animal being decimated towards extinction. A timely contribution to such data would have been proactive. Instead, even in the face of a specific request for assistance (by RRP), nothing was done until horns could be recovered from treated rhino that had fallen. In the current circumstances, a reliance on the absence of data, which you yourself were in the best position to contribute towards, in support the negative findings of the Article, is disingenuous.

Regarding rhino horn structure and qualities there is, however, more recent relevant literature available; amongst others, a paper entitled "A Review of Rhinoceros Horn" by Yang (2011) which contains valuable information and dispels a number of myths surrounding rhino horn, which were relied on by the authors of the Article. We set out some relevant excerpts below:

> *"The central structure is referred to by Hieronymus as a "medullary cavity;" in actuality, this structure has several gas spaces or one large space occupying the width of the core."*



"Figure 2: The keratinous filament. The concentric orientation of the keratin sleeves, the gas spaces, and the core structure are labeled [Chernova 1998]."

This extract and image can be found under the heading "0.3.1 the Filament" on page 4 of the paper by Yang.

"The horn from a live animal - fresh horn - has a water content of wt.20%; Kitchener and Vincent found that horn can be immersed in water to a saturated value of 40 wt.% water-wet horn [McKittrick 2010]. The insolubility of α -Keratin was mentioned earlier; the filaments did not uptake the water molecules. Instead, the additional water fully hydrated the matrix and likely filled the gas spaces within the cores of the keratin filaments as well [McKittrick 2010].

This extract can be found under the heading "0.5.2 Hydration" on page 7 of the paper by Yang.

24. *"Horn structure suggests differential resistance to wear (Hieronymus et al. 2006), which predicts differential distribution of the chemical compounds following infusion.* We could also not 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."* [emphasis added]

(*The underlined text together with the material from Yang 2011 above is relevant to the discussion of RRP data that follows below.)

A survey was conducted to establish whether there were any detrimental effects on the horn structure or strength. Given the loads and forces that these horns are commonly subjected to, the absence of visible exterior damage gives an indication that the horn integrity is not compromised. The authors have themselves had hands on "treated horns" yet rely on an absence of literature to draw to a point of indecision when the same horns that have been used to discredit infusion could have been relied on to confirm no noticeable structural damage as a result of the treatment.

RRP understands that Hofmeyr had previously concluded:

"No macroscopic sign could be seen if the core horn structure had changed in any way."

25. *"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."*

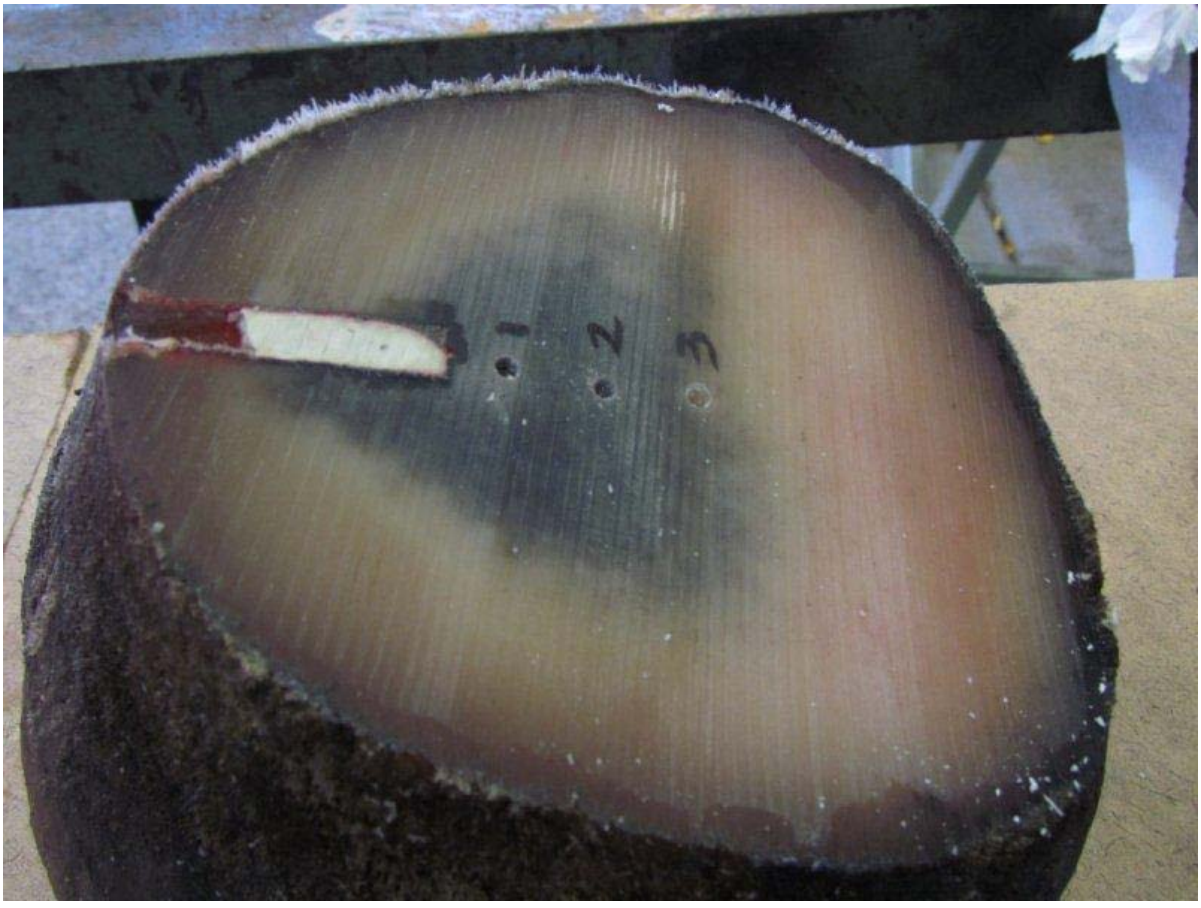
This is not correct and implies a level of disinterest by RRP. We have been prevented from doing so by law. The necessary permit is in the process of being issued after an application procedure that has been drawn out over years.

26. ***"Figure 2.*** *Transverse cut through a recovered posterior horn after infusion with a mixture of indelible dye (pink colour) and ectoparacitides illustrating failure of the procedure to distribute dye evenly throughout the papillary cornified epidermis of a white rhino horn. This result is characteristic of* ***all horns sampled*** *post infusion treatment."* [emphasis added]

This image warrants closer inspection. A red hue seems to be detectable in areas of the horn material remote from the drill hole for the infusion probe.

Below is another photograph that also originated from SANParks and distributed via email as part of a set, which included the image used in the Article. The image below shows, this time more prominently, (red) discolouration of or within the horn material. As there are no blood vessels in a rhino's horn, this discolouration cannot be attributed to blood. Hence it suggests that there was, in this horn, a degree of infusion of the dye after all. This image was not included in the Article, although its results actually would have supported the author's assessment (*underlined above) that the (more) porous or less dense horn material surrounding the core is more likely to infuse to a greater extent than the actual cortex would – but not their claim that horn infusions are a technical failure in absolute terms.

The claim that "all horns sampled" resemble the above image that was used in the paper is (at least on a comparison of the actual photographs) misleading. It seems an important detail to leave out of an objective scientific paper intended to shed light on a little-understood methodology - especially, where that paper is one that relies so heavily (in fact, exclusively) on a "visual inspection" (in the stated absence of formal chemical testing).

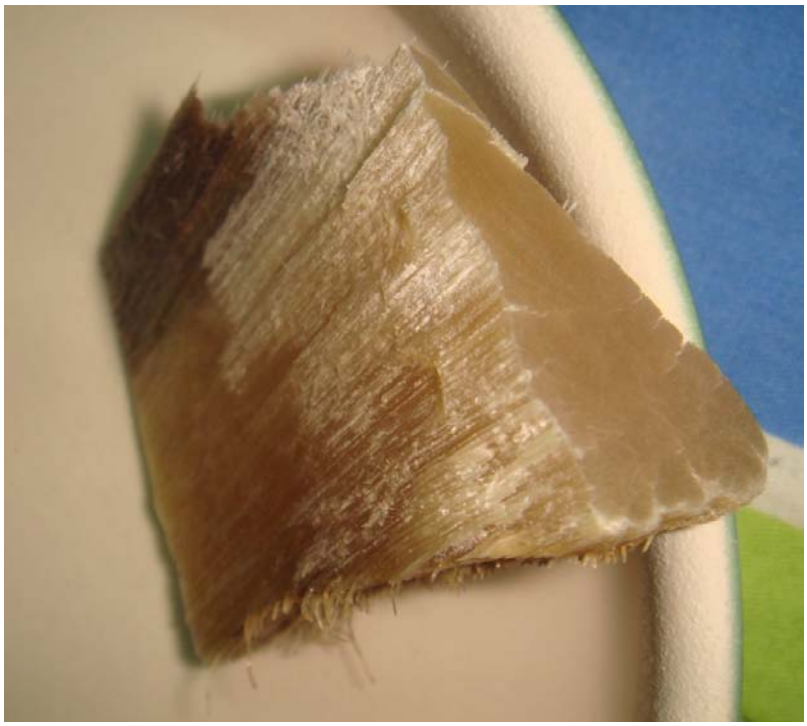


Original photograph (above)

Photograph with filter applied (above)

The photograph above also indicates that three samples were taken for analysis from this horn. The sample sites are position only in the denser, central core area. This would be the area least likely to be penetrated by the infusion liquid. RRP understands that: *"For each horn, small core samples (1 cm in depth) were collected at least 1 cm from the edge of the drilled application hole. In some instances a sample at 2 cm and 3 cm distances were also taken."*

We point out that there is no red hue in the polished back-lit cross slice taken from a rhino horn, in Figure 1 of the Article above. For the purpose of further comparison, we copy below two photographs of sections of untreated rhino horn (which are also absent any red hue):



27. *"Samples from five sets of white rhino horns retrieved after horn infusion with indelible dye combined with ectoparaciticides (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 infusion9) noted no visible discoloration through the papillary cornified epidermis of the horn (Fig. 2).* ***Even in the absence of formal tests for ectoparasiticides or their metabolic derivatives in the papillary cornified epidermis, it is unlikely to be present given the chemical mixture of ectoparasiticides with indelible dye as part of the application procedure and the fact that there was no penetration of the indelible dye into the horns****."* [emphasis added]

We deal below with the "circumstances" under which Cooper of EKZNW contributed to the Article.

It is not apparent which of the authors made a visual analysis of which of the dissected horns (in the possession of SANParks) or drill samples (from the EKZNW horns).

It is also not apparent what is meant by *"visual discoloration"*. Under Figure 2 of the Article, it is stated that "*Transverse cut through a … horn … illustrating failure of the procedure to distribute dye evenly throughout the papillary cornified epidermis... This result is characteristic of all horns sampled post infusion treatment*". The underlined portion implies a relatively absolute criterion that has been set by the authors and by which they have judged the treatment a failure.

Based on the literature regarding rhino horn structure (see Hieronymus 2006, referred to in the Article and *underlined extracts above, and Yang 2011, referred to by RRP above) and the limited data on which we have to comment, it is likely that the dye may manifest in the "limited spaces" between solid horn material structure in a pattern corresponding to the horn density (and occurrence of such spaces) and not have the effect of acute horn discoloration in all horns (seemingly the test that has been applied and what the authors are finding against).

Moreover, RRP understands that Cooper's contribution related to *"drill core samples"* – meaning drill shavings taken from the dark core material towards the centre of the horn. The dye is less likely to penetrate this part of the horn and would be far less likely to visually manifest in this material.

A microscope to view the horn material (and especially any drilled samples) with some degree of magnification seems a reasonable measure in the circumstances (but would of course still not be useful in drawing any firm conclusion as to an absence of ectoparasiticides).

No analytical chemical or toxicology test results are relied on. The visual inspection does not venture beyond the macroscopic (i.e. a visual inspection by the naked eye under ambient light conditions, as RRP understands it).

It is unclear whether the authors obtained any additional relevant detailed information from EKZNW with regard to the drilled samples included in this study. Some of the animals

treated in EKZNW did not have infusions performed on their back (posterior) horns due to the small size of the horn, which made fitment of a probe difficult/impossible. A percentage of the animals treated on other properties have also not had their back horns infused for the same reason. In addition to this, the infusion procedure does sometimes not last for the full intended duration. It is shortened if the animal starts showing unnatural signs of distress or presents with symptoms indicative of an adverse reaction to the immobilization.

These are matters, potentially relevant to the treated horns referred to in the Article, that RRP could have assisted with if consulted with respect to interpreting the data. At the very least, such possibilities should have been ruled out with respect to the small data set that was "analysed". (RRP has still not received the "promised" DNA samples that would allow us to identify the rhinos and cross-reference our treatment records.)

In addition to such considerations, possible changes in an evolving infusion formulation is, for example, another issue that the Article completely overlooks when concluding that all of the remaining treated horns of rhinos still alive are by implication covered by its "negative findings". Instead, the Article pronounces that all treatments performed have been ineffective without exception and without the slightest concession that any (or even just a small amount) of the remaining 276 treatments may still be providing the animals in question with a reasonable measure of protection from poachers (and should certainly not be considered "toxin free").

This cannot be considered a measured approach to reporting on what is, we submit, an uncompelling data set.

28. *"All evidence indicates wide-scale failure of application efficiency."*

A discussion of relevant RRP data follows:

The ongoing field trials and observations of RRP have provided an indication that infusion is viable. From these have come evidence of penetration and travel of the treatment formulation into various horns. The following examples have relevance:

a. The photograph that follows shows the pressurized canister that is used to administer the infusion liquid. The volume of infusion liquid and pressure in the canister are both reduced during infusion treatment of a horn.

b. A second photograph is copied below. A rhino with a treated horn had been re-darted. A sample hole was drilled a short distance from the original infusion site. Stained horn shavings are visible. This demonstrates travel of the formulation through the horn material from the application site to the drill sample site.

c. A third photograph, shows a snapshot taken from video footage. The back horn of a rhino is being treated. A second hole for a microchip is being sealed with putty at the same time. The putty can be seen as a small (beige coloured) bulge to the left of the infusion probe. The video illustrates a repeated outward displacement of the putty.

This is evidence of travel of the fluid through the horn material driven by the applied fluid pressure and thus movement of the formulation from the treatment site into the horn material.

A fourth photograph illustrates the same occurrence, with putty being displaced out of a microchip hole on the right of the probe.

d. A fifth photograph and a snapshot image from a video follow, which both show treatment of a back horn of a rhino. A second microchip hole spaced apart from the infusion site is being pointed to in the first image. The formulation has travelled across the horn material from the infusion site. The stained liquid has filled and is running out of the second hole.

The video from which the following snapshot is taken shows the fluid running out of the microchip hole on the left.

e. It has also been observed, when treating a horn that the formulation has travelled across the horn from the infusion site and is weeping through the surface on the opposite side.

The “information” obtained by the authors at SANParks from EKZNW (via Cooper) was made avaiable in conflict with an agreed arrangement (put in place by PPF) in terms of which all data resulting from a pilot project carried out on the EKZNW properties was to be used for joint ongoing research to benefit the horn devaluation program. Proper tests were to

be concluded (through cooperation between PPF, EKZNW and RRP) and the results/outcomes used either to confirm or make changes to the infusion procedure and future treatments. We were never involved and not even made aware that data had been collected and sent to SANParks for use in the Article. This information came to us after the fact. When questioned on the issue Cooper admitted sharing (on request by the SANParks authors) the information in question but gave no indication of any further contribution that would have him cited as a co-author.

It should be noted that RRP had specifically refused to proceed with the PPF/EKZNW pilot project once it learnt of the horns dissected by SANParks (on 27 August 2013). SANParks had undertaken to provide RRP with samples and we wanted to conduct tests before doing more treatments. We were convinced to proceed (in a meeting attended by PPF, RRP and the University of Pretoria on 31 August 2013) on the basis that the project's main objective was to illustrate that horn devaluation (as a concept) would have a deterrent effect on poaching in a large open conservation area and that data would be collected and used (jointly, with full involvement of RRP) to improve the devaluation program.

RRP is still hopeful that we may yet receive samples of these horns from SANParks and EKZNW. The irony is that the samples have apparently been harvested mainly with a view to analysing the horn core will not allow for the proper analysis which we would consider most useful for ongoing research and development.

As to the presence of dye, if a "layman's" test is applied by "experts" it does not elevate the finding to "science". RRP would not (with all due respect) consider the authors to be experts in this field of analysis. Furthermore, given the remainder of the Article and information provided in this document, it can hardly be said that the authors are independent and objective.

With regard to the presence of a toxin, the visual inspection (particularly in the light of the data provided by RRP) is simply not and can never be a test (scientific or otherwise). The consequences of anouncing a conclusion on this basis is significant. Firstly, treated rhino are pronounced toxin free and thus viable targets and, secondly, the warning to would-be consumers of any poached rhino horn is withdrawn. It is assumed that the authors must, reasonably, have considered these issues (alternatively, they were recklessly overlooked). If they were not overlooked, then the intended broadcast itself is reckless.

In contrast to the declarations of the Article regarding an absence of ectoparasiticide, RRP understands that one of the authors, Hofmeyr, was initially of the view that:

> *"It is uncertain what the distribution of toxins within a horn might be following application of the substance through infusion. It is however likely that toxins may have similar constraints as noted for the colorant given that these are mixed in the product. The robust testing of samples taken should shed light on this aspect."*

And that:

> *"A chemical analysis is to be undertaken to check on the degree of infusion of the toxin."*

Maintaining deterrence effectiveness

29. *"Disregarding application efficiency, maintaining deterrence effectiveness may be challenging. Rhino horn continually grows …."* and *"Infusionists advocate treatment effectiveness for 3-4 years (Rhino Rescue Project 2013)."* and "*Horn structure with hardness provided by the occurrence of calcification in melanized cornified epidermis (Hieronymus et al. 2006), suggests that passive diffusion of the chemical compounds is unlikely to result in treatment of new cornified epidermis."* and *"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 continuously added, and higher wearing rates for treated parts of the horn, suggest that larger and larger fractions of the horn will comprise untreated cornified epidermis. This means that over time, attractiveness of the horn will increase which could influence incentives for poachers."*

The information regarding growth corresponds to our initial estimates – to be confirmed with the collection of other relevant data at the end of our first four year horn growth cycle, at the end of this year.

*****

This section of the Article (science challenges) directly contradicts the section on legal and ethical implications – if the treatment is a (technical) failure, there can be no ethical and legal ramifications. If there are legal consequences it is implied that the procedure does, in fact,

work…? An issue for some consideration is broadcasting as the Article does that the procedure does not work at all and the treated horns carry no toxins based on a visual analysis of a minuscule percentage of horns.

Logistical challenges

30. *"Ultimately though, more often than not, the chance of getting treated horn may be a large enough disincentive to overcome price incentives."*

This statement contains an important concession by the authors as it *confirms* that the risk to rhino poachers of getting treated horns could potentially be enough of a disincentive to the poacher to avoid reserves on which treatments had been performed. If this is true, how can the entire concept of horn devaluation be dismissed as an "unnecessary deception"? Is it not imperative for the conservation community to explore all avenues available to it in order to reduce poaching figures?

31. *"Logistical requirements increase when the size of areas and populations increase. Recently, the Sabi Sand Game Reserve treated about 15 % of white rhinos present, while Ezemvelo KZN treated approximately 65 % of rhinos in the Ndumu Game Reserve and the Tembe Elephant Park along the Mozambique border."*

It is unclear whether the authors obtained the permission of the above-mentioned properties to divulge this sensitive data. This disclosure arguably endangers not only treated animals, but also the remaining 85% and 35% (respectively) of untreated animals on these properties. Surely, the point could have been made without referring to the reserves by name.

32. *"Costs amount to US$1000 per rhino, inclusive of helicopter time and vehicles, but excluding costs of drugs and veterinary expertise (Andrew Parker, personal communication10)."*

In fact, average fixed costs per procedure, inclusive of drugs and veterinary expertise, amounts to between R6500.00 and R6800.00 per animal (of which 30% contributes to insurance cover for the procedure). Had the authors made any kind of effort to contact RRP directly, they would have been aware of this fact.

33. *"In addition, the infusion procedure takes at least 30 minutes per rhino (Rhino Rescue Project 2013). Together with searching, immobilization, treatment, reversal and preparation of drugs and equipment, a team can expect 90 minutes to complete one rhino, allowing for a maximum of four rhino a day if the area is large and finding rhinos is difficult."*

According to our treatment schedules and daily breakdowns of all treatments performed over the course of the past four years, the daily average totals 6.7 treatments (i.e. up to about 7 treatments per day). This is a fair number.

34. *"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 there are no permanent visible external markers available.*"

In fact, there are several visible external markers available. The decision not to use any thus far has been deliberate, so as to not make untreated animals on the same properties bigger targets. In its most basic form, ear tags are a commonly used visible marker, but RRP is also considering other methods.

35. *"Most commonly used permanent markers are gum tattoos or microchip insertions, neither of which is visible in free-range wild animals. Invasive techniques like ear notching or tagging, is the only other alternative, which is effective in small populations, but becomes difficult for larger populations."*

This exercise should not become difficult in larger populations – if an animal has been immobilized for treatment, attach the visible marker simultaneously? This would be the procedure followed irrespective of whether there are 10 or 100 animals receiving treatment.

Reduction of poaching

36. *"The conceptual challenges of chemically treating rhino horn highlighted earlier, predicts variable effects on poaching rates. To date, infusionists treated 230 [276] 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%),.."*

A reduction in poaching is supposedly the ultimate success measure as per the opening paragraph of the Article. If the poaching rate of treated rhinos is significantly lower than the national poaching rate (as the above data would seem to suggest) how can the authors still label devaluation an "unnecessary deception" or a "failure" in the face of these indications as to its actual deterrent value?

37. *"…but confidence intervals overlap. In Sabi Sand Nature Reserve, we know of three 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 data11), clearly challenging the deterrence value of horn treatment to poachers."*

Out of 14 properties randomly sampled during 2013 (between which a total of 119 animals had been treated up to that point in time) and all of whom had suffered losses due to poaching prior to implementing horn devaluation procedures, only 3 reported further losses. Some of the very first properties RRP ever worked on – some four years ago – have still not experienced further poaching incidents, despite making no additional changes to their existing security measures. This compelling evidence highlights the need to distinguish between **method** and **concept**. As a poaching intervention, the concept of horn devaluation has achieved successes that cannot be ignored.

38. *"Prior to horn infusion, poachers killed nine rhinos in Ndumo Game Reserve and Tembe Elephant Park combined."*

The timeframe relevant to the above statement is unclear. Had 9 rhinos been poached in these two reserves over the course of a year, a month or a week? Without such basic information, no assumptions can be made regarding the success or failure of horn infusions as a poaching deterrent in these reserves.

39. *"Here, incursion rates also decreased dramatically, with 29 illegal entries by poachers recorded for the three months prior to the infusions and five for the three months after treatment."* [emphasis added]

Based on feedback given to us by PPF, the reserves themselves attributed this reduction almost exclusively to the implementation of the horn treatments. The reported loss of only 2

animals in 11 months on two of the hardest hit reserves (as they were described to us) in KwaZulu-Natal, is a triumph, no matter how one tries to downplay those results. This pilot project came about as a result of a demand issued by SANParks that the horn devaluation concept first be tested in a large open conservation system. Although this was done, and the results were overwhelmingly positive, it would appear that the goal posts were simply shifted again. It is apparent that SANParks was never looking to make this strategy work, but instead is grasping at straws to accomplish the opposite. One can only speculate as to the reasons for this, although the following articles published on the same day (see links below) do shed some light on the chaotic state of affairs within the KNP:

http://m.news24.com/news24/Green/News/SANParks-plans-rhino-rescue-operation-20140720

http://www.timeslive.co.za/local/2014/07/20/sanparks-denies-sale-of-kruger-national-park-rhino

Conclusion

40. *"To be successful, a critical mass of the rhino horn population needs treatment, with more demanding logistical requirements when areas and population sizes increase."*

Shouldn't an organisation that prides itself on being at the forefront in the fight against poaching, exhibit the willingness to try any and all possible tools available to them at least once before dismissing them as "failures" (particularly under the current circumstances)? SANParks was offered an opportunity to trial horn infusion (with the emphasis on **trial**, as this has always been an ongoing experiment) in certain areas of the KNP at no risk to them (it could hardly have made matters worse) i.e. none of their own resources would have had to be utilised, the project was fully funded and they were not expected to make available their own time, money or staff. All that was requested of them was access to the poaching "hotspots" we were supposed to work in. If the campaign were a massive success in keeping rhinos alive, the KNP could have claimed all the credit. If it were a failure, they could have blamed it squarely on RRP – yet they refused to even give it a chance. Why...? (It should be noted that this occurred *before* the discovery of the, now infamous, "Kruger horn" discussed at length in the Article, so this could clearly not have been the reason for their resistance, although it did subsequently become a very convenient excuse.)

41. *"This imposes several logistical challenges at potentially high costs to authorities."*

A rather hefty donation towards implementing and refining this methodology within the KNP was made available by an international donor to PPF in February 2014. Costs to authorities would therefore have been minimal.

42. *"Relying on publicity to deter poachers also relies on publicity convincing managers that chemical treatment of horns through infusion will secure rhinos. Poachers will benefit and managers will lose when the bluff of horn treatments fails."*

With this claim, the authors fail to acknowledge the growing field of conservation psychology. Conservation psychology examines the effect that social marketing and publicity have on the actions of individuals within populations when it comes to participation in conservation activities. For example, the Health Belief Model (Rosenstock, 1990) postulates that behaviours are usually performed to avoid some negative consequence in the future i.e. the likelihood that a person would engage in a behaviour is a function of two factors: perceived threat and outcome expectancies. Use of this model could be a powerful tool in rhino conservation if marketing messages that dis-incentivise poaching (by reinforcing the idea of negative consequences) are combined with law enforcement (which increases risk to the poacher) and asset devaluation (which reduces the reward to the poacher).

43. *"Chemical horn infusion is thus not a poaching deterrent, but an unnecessary deception."*

Poaching rates of treated animals would seem to suggest otherwise. The truth is that RRP has lost the same number of animals to poachers in ***four years*** that the KNP loses over ***two days***. For the sake of our rhinos, shouldn't that be the proof in the pudding?

26 July 2014

[This document includes some minor additions and editorial corrections over the version submitted to Carte Blanche on 22 July 2014. For a copy of the original document showing these changes, please email: rhinorescueproject@gmail.com]

“Addendum A”

A response to the conclusions in the 'Ferriera paper' regarding the application efficiency of rhino horn infusion (21 July 2014**)**

In the sub-paragraph 'Application efficiency' under the heading 'Science challenges' the Ferreira paper concluded as a 'fact that there was no penetration of the indelible dye into the horns.' The conclusion was based on one assessment only: a visual inspection of a transverse cut through a recovered posterior horn after infusion with a pink dye (Figure 2), leading to a judgement by a person whether or not Fig 2 exhibited any spread of pink dye through the horn. This clearly constitutes a very subjective way of assessing the success or not of dye infusion into the rhino horn: the conclusion would depend on how the person in general sees colours and how trained the eye is in this field of observation.

The Ferreira study is being forwarded as a scientific paper and the reader would expect some scientific evidence to corroborate the rather subjective judgement of a visual inspection by a person.

Firstly the dye should be identified and secondly the spread (or not) of the dye through the horn established from a concentration profile of the dye sampled at different positions in the plane of the transverse cut (by drilling known amounts of horn followed by chemical extraction and analysis of the drillings).

Secondly the procedure should be repeated for the ectoparasiticide as it cannot be assumed that the transport behaviour of the ectoparasiticide through the horn would be the same (or even similar) to that of the dye.

It also should be kept in mind that the visibility (or not) of the dye with the naked eye does not constitute the success (or not) of the infusion.

Dr HF Strauss

"Addendum B"

CURRICULUM VITAE (abbreviated)

Heinrich Frederick Strauss

Birth	14 June 1951, Heilbron South Africa
Education	Matric – Hendrik Verwoerd High School Pretoria, 5 distinctions (1968) BSc (Chemistry and Physics), University of Pretoria (1972) THED (Transvaal Higher Education Diploma), Pretoria Teachers College, *cum laude*, 1972 MSc (Organic Chemistry), University of Pretoria, *cum laude*, 1976 DSc (Chemistry), University of Pretoria, 1980 MBL, University of South Africa, 1994
Employment	Lecturer, Chemistry Department, University of Pretoria, 1973 - 1980 Senior lecturer, Chemistry Department, University of Pretoria, 1981 - 1982 Post-doctoral Research Fellow, Department of Chemistry, University of Geneva, 1981 Associate professor, Chemistry Department, University of Pretoria, 1983 - 1985 Chief Forensic Analyst, Forensic Science Laboratory, South African Police Service, 1986 Director Forensic Services, Forensic Science Laboratory, South African Police Service, 1987 - 1994 Head, Forensic Science Laboratory, South African Police Service, 1988 - 1994 Head, Analytical Chemistry Unit, Sasol Technology R&D, 1994 - 1998 Head, Product Beneficiation Group, Sasol Technology R&D, 1999 - 2001 Head, Sasol Fuel Research, 2001 - 2006 Consultant and technical advisor, Parc Radon Gas Monitoring, 2006 - current
Awards	HF Verwoerd Award for the best student in the academic, sport, and cultural areas combined, Hendrik Verwoerd High School (1968) Honorary Certificate and Bursary for the best THED student, Pretoria Teachers College (1972) Protea Holdings Prize for the best MSc dissertation in chemistry 1977 DF du Toit Malherbe Prize, Chemistry Department, University of Pretoria (1980) Ernest Oppenheimer Memorial Trust Bursary (1981)
Publications	Scientific: 16 Text books: 2

Are 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 of the methods advocated is infusing rhino horns with chemicals and dye. Promoters of this method claim this procedure renders the horn useless. It also, however, carries potential risk to the end user when ingesting poisoned horn. We visually examined white rhino horn that had been treated, examined available literature and obtained expert opinion to assess several assumptions and risks associated with the approach. We found the information upon which the assumptions are based to be weak, and refute the 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 when dealing with the rhino poaching threat.

Introduction

Poaching continues to threaten rhinos despite intensified anti-poaching campaigns (Ferreira et al. 2012). Evaluation of multi-pronged approaches that include demand reduction, provision of horn or elimination of poaching through intensified anti-poaching campaigns (Ferreira and Okita-Ouma 2012), illustrates that integration of approaches carries the largest benefits for a suite of conservation outcomes (Ferreira et al. 2014). Some options, such as the provision of 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 disincentives created do not outweigh the incentives of financial benefits (see Ferreira et al. 2014). Rangers' efforts require matching initiatives directed at disrupting transnational crime networks, at a scale never before faced by conservationists (Dalberg 2012). Authorities, however, may also reduce supply through approaches such as treating live rhino horn chemically to make it inconsumable by humans (Rhino Rescue Project 2013). Typically, horn treatment is an infusion of a compound or combinations of compounds into the horn of a live rhino. The most common infusion comprises an indelible dye and 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 publicity of horn infusions. We then highlight legal and ethical challenges. Third, we focus on the scientific basis of the potential of chemical deterrence, application efficiency and the maintenance thereof. We also consider the logistical requirements of infusing a large enough number of rhinos in a population. Reduction in poaching rates, however, is the ultimate success measure. We check whether this is the case.

Conceptual challenges

The infusion of chemical substances into rhino horn 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 treated horn (Rhino Rescue Project 2013). In cases where infusions comprise indelible dye as well, proponents predict the horn to be considered as worthless for ornamental use. The belief behind such chemical treatments is that it provides a mechanism to devalue the horn and thus disturb the financial market. A key element as part of the initiative is that wide-scale publicity of chemical treatment of horn should deter poachers.

Prices paid to poachers for horn provide significant financial incentives (Ferreira et al. 2014), which most likely relate 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. When treating horns, infusionists assume that poachers will not be able to sell such horns to the end-users as they would be considered unsuitable, therefore reducing the demand for treated horns and thus financial value. Removing the price incentive results in disincentives outweighing incentives and poaching rates therefore decline (Ferreira et al. 2014).

A key challenge arises, however, because infusionists create two rhino horn commodities – treated and untreated horn. Increasing supply of treated horn (or horn perceived to be treated), assumed to have no value and thus demand, 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 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 may 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 (e.g. Izzo 2010), which illustrates the potential of illegal supply innovation to disturb the market disruption strategy. Demand and supply interactions predict rapid escalating prices for untreated horn and consequent 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 horns, and additionally, because poachers are not the end-users. Therefore, there is no reason for treated horn, especially if the chemicals are not visible, not to be sold. 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 effectively has no effect on supply and demand dynamics (Jain 2006) and hence 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 successes 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 and 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 existing supplier replaces the product missing following removal of an established supplier, if demand is high enough. This dynamic may explain why daily poaching rates in South Africa increased following the removal of pseudo-hunting (non-bona fide hunters hunting rhinos as sport hunters, Department of Environmental Affairs, Unpublished data). 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 disrupted the supply. The reduction in demand for unspoiled products does not result due to spoiled end-user products (Jain 2006). None of the demand-reduction theories proposed were tested before being implemented, including the effect on humans, which will be difficult to achieve given that the use of rhino horn is not legal in end-user countries (Milliken and Shaw 2012). This makes it difficult to obtain reliable information of 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 his 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 is illegal in most countries (CITES 2010, 2011), but illegality of consumption thereof is uncertain. If authorities allowed legal poisoning of illegal substances, widespread application to reduce worldwide illegal drug trades should result, an outcome never realised. The end-consumers will 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 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 the Parties (Cooney and Abensperg-Traun 2013). In contrast, stakeholders living in rhino range states expect that authorities will protect rhinos and effectively fight crime. The application of horn infusions as a poaching deterrent may thus contribute to such 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 will be temporary because range State stakeholders would also expect reduction in poaching rates.

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, personal communications[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 pre-treatment *vs* post-treatment, or control *vs* experimental comparisons.

An immediate health risk to the rhino is associated with immobilization of the individuals, with the anaesthesia procedures resulting in at least one white rhino dying during the horn infusion process (Beeld 2012). Experience of immobilizing rhinos to notch, translocate or treat injuries suggests that the typical 30 minutes to complete the process (Rhino Rescue Project 2013) would be considered long (personal observations). In addition, this does not include effects of chasing rhino during the actual darting operation. At least one study illustrated that rhino immobilizations 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 following capture (SANParks, unpublished data[2]). Multiple captures of rhinos, particularly young rhinos, may carry chronic stress consequences given requirements of re-treatment every 3-4 years (Rhino Rescue Project 2013). Horn infusionists reported anecdotally no detrimental effects on rhino health following capture for treatments (Rhino Rescue Project 2013), but no formal evidence is available.

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

Science challenges

Conservationists strife 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 ectoparasiticides 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

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[2] Available from Dr Markus Hofmeyr, Veterinary Wildlife Services, Skukuza, markus.hofmeyr@sanparks.org
[3] Dr Johan Marais, Faculty of Veterinary Science, University of Pretoria

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 anti-parasitic 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 defined human health risks. Most commercially available ectoparasiticide products are relativity safe to humans and unlikely to have any serious health consequences in the quantities ingested from known rhino horn products (Johan Marais[5] and Gerhard Steenkamp[6], personal communication).

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

In addition, it is an assumption that people will 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 contains 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) and 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 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 (Fig. 1). Most importantly, the variations in melanin content and calcification result in differential wear, the key mechanism for horn shape (Hieronymus et al. 2006).

[4] Werner Myburgh, Peace Parks Foundation
[5] Dr Johan Marais, Faculty of Veterinary Science, University of Pretoria
[6] Dr Gerhard Steenkamp, Faculty of Veterinary Science, University of Pretoria

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.

Infusion of rhino horns is not complex. Veterinarians immobilize a rhino using standard veterinary techniques (Standard operating procedures for capture, handling and transport of wild animals, SANParks[7]). Following successful immobilization, holes are drilled (~10 mm in diameter) into the centre of the horn and an applicator inserted. A compressor, fitted to the applicator, drives infusion of the chemical combination under 9-bar pressure for 20 minutes (Andrew Parker, personal communication[8]). After the procedure, the applicator is removed, the hole plugged with a resin, and veterinarians administer an antidote to the rhino for recovery 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. We could also not 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.

[7] Available from Dr Markus Hofmeyr, Veterinary Wildlife Services, SANParks, markus.hofmeyr@sanparks.org
[8] Andrew Parker, Former Chief Executive Officer, Sabi Sand Game Reserve, ceo@sabisand.co.za

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

Samples from five sets of white rhino horns retrieved after horn infusion with indelible dye combined with ectoparaciticides (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 (Fig. 2). Even in the absence of formal tests for ectoparasiticides or their metabolic derivatives in the papillary cornified epidermis, it is unlikely to be present given the chemical mixture of ectoparasiticides with indelible dye as part of the application procedure, and the fact that there was no penetration of the indelible dye into the horns. All evidence indicates wide-scale failure of application efficiency.

Maintaining deterrence effectiveness

Disregarding 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 horns grow at 5-6 cm per year (Pienaar et al. 1991, Rachlow and Berger 1997), while posterior horns (i.e. small horn behind the nasal horn) grow at 2 cm per year (Rachlow and Berger 1997).

Infusionists advocate treatment effectiveness for 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 the occurrence of calcification in melanized cornified epidermis (Hieronymus et al. 2006), suggests that passive diffusion of the chemical compounds is unlikely to result in treatment of new cornified epidermis. In addition, horn wear determines horn shapes and sizes (Boas 1931) with the higher concentration of melanin and calcium salts in the centre of

[9] Data provided by Dave Cooper, Ezimvelo KZN, dcooper@kznwildlife.com

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 continuously added, and higher wearing rates for treated parts of the horn, suggest that larger and larger fractions of the horn will comprise untreated cornified epidermis. This means that over time, attractiveness of the horn will increase which could influence incentives for poachers.

Logistical challenges

The unpacking of how incentives and disincentives influence a person's decision to poach suggests a critical mass of horn needs to be treated in a population to deter poachers. Theoretically, fractions larger than 50 % introduce probabilities that a poacher will encounter more often than not 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 some suitable horn. Ultimately though, more often than not, the chance of getting treated horn may be a large enough disincentive to overcome price incentives.

Numbers 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, the Sabi Sand Game Reserve treated about 15 % of white rhinos present, while Ezemvelo KZN treated approximately 65 % of rhinos in the Ndumu Game Reserve and the Tembe Elephant Park along the Mozambique border. Costs amount to US$1000 per rhino, inclusive of helicopter time and vehicles, but excluding costs of drugs and veterinary expertise (Andrew Parker, personal communication[10]). In addition, the infusion procedure takes at least 30 minutes per rhino (Rhino Rescue Project 2013). Together with searching, immobilization, treatment, reversal and preparation of drugs and equipment, a team can expect 90 minutes to complete one rhino, allowing for a maximum of four rhino 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 there are no permanent visible external markers available. Most commonly used permanent markers are gum tattoos or microchip insertions, neither of which is visible in free-range wild animals. Invasive techniques like ear notching or tagging, is the only other alternative, which is effective in small populations, but becomes difficult for larger populations. Given these logistical challenges, this approach is only feasible in small and isolated populations.

Reduction of poaching

The conceptual challenges of chemically treating rhino horn highlighted earlier, predicts variable effects on poaching rates. To date, infusionists 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 three rhinos with infused horns being killed since the inception of

[10] Andrew Parker, Former Chief Executive Officer, Sabi Sand Game Reserve, ceo@sabisand.co.za

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.

Prior to horn infusion, 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 three months prior to the infusions and five for the three months after treatment. Just prior to 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 rhino present in both reserves and subsequently poaching pressure seemed to shift to other rhino populations further south of the Mozambique border (personal observations). It is thus difficult to conclude reduction in poaching rates associated with infusion of horns with a chemical deterrent.

Conclusion

Our assessment highlighted key flaws in the assumptions that the treatment of rhino horn will lead to declines in poaching incidences. 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.

Much 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. At least one of the compounds of the most commonly used treatment has some evidence supporting its harmful nature to humans, but the structure and growth dynamics of rhino horn suggest that the application and maintenance efficiency 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 were not true.

To be successful, a critical mass of the rhino horn population needs treatment, with more demanding logistical requirements when areas and population sizes increase. This imposes several logistical challenges at potentially high costs to authorities.

These concerns highlight that authorities may carry substantial risks and have high uncertainty if attempting 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 publicity convincing managers that chemical treatment of horns through infusion will secure rhinos. Poachers will benefit and managers will lose when the bluff of horn treatments fails. Chemical horn infusion is thus not a poaching deterrent, but an unnecessary deception.

References

Beeld 2013. *Renoster plan eindig tragies.* http://www.beeld.com/Suid-Afrika/Nuus/Renoster-plan-eindig-tragies-20120209. Accessed 4 May 2013.

Bingbin H. 2012. Puffer perils. http://chinawatch.washingtonpost.com/2012/04/puffer-perils.php. Accessed 3 March 2014.

[11] Ken Maggs, SANParks, ken.maggs@sanparks.org

Biggs D, Courchamp F, Martin R, Possingham HP. 2013. Legal trade of Africa's rhino horns. *Science* 339: 1038-1039

Board of Agriculture. 1999. *The use of drugs in food animals: Benefits and risks.* National Academy Press, Washington DC, USA.

Boas JEV. 1931. Hörner. In: Bolk L, Göppert E, Kallius E, Lubosch W, editors. *Handbuch der vergleichenden anatomie der wirbeltiere*. Urban & Schwarzenberg, Berlin.

Bonier F, Quigley H, Austad SN. 2004. A technique for non-invasively detecting stress response in cougars. *Wildlife Society Bulletin* 32: 711-771.

Carlstead K, Brown JL, Seidensticker J. 1993. Behavioral and adrenocortical responses to environmental changes in leopard cats (*Felis bengalensis*). *Zoo Biology* 12: 321–331.

Child B. 2012. The sustainable use approach could save South Africa's rhinos. *South African Journal of Science* 108 , Art. #1338, 4 pages. http://dx.doi.org/10.4102/sajs.v108i7/8.1338.

CITES. 2010. *Illegal killing of rhinoceros in South Africa.* Fifteenth meeting of the Conference of the Parties Doha (Qatar) CoP15 Inf.32 www.cites.org/comon/cop/15/inf/E15i-32.pdf. Accessed 25 January 2012.

CITES. 2011. *Conservation of and trade in African and Asian rhinoceroses.* Proposal by the European Union (EU) and its Member States for the 61st meeting of the CITES Standing Committee. SC61 Doc. 45.2. www.cites.org/eng/cop/15/doc/E15-45-01.pdf. Accessed 24 January 2012.

Cooney R, Abensperg-Traun M. 2013. Raising local community voices: CITES, livelihoods and sustainable use. *Review of European Community and International Environmental Law* 22: 301-310.

Dalberg. 2012. *Fighting illicit wildlife trafficking: A consultation with governments.* WWF International, Gland, Switzerland.

Ferreira SM. 2013. An update on rhino research and surveys in SANParks. SANParks, Skukuza. Unpublished.

Ferreira SM, Deacon A, Sithole H, Daemane M, Bezuidenhout H, Herbst M. 2011. From numbers to ecosystems and processes: A mechanistic approach to monitoring. *Koedoe* 53: 193-204.

Ferreira SM, Okita-Ouma B. 2012. A proposed framework for short-, medium- and long-term responses by range States to curb poaching for African rhino horns. *Pachyderm* 51: 52-59.

Ferreira, S.M., Botha, J.M. & Emmett, M. 2012. Anthropogenic influences on conservation values of white rhinos. *Pubic Library of Science ONE* 7(9): e45989. doi:10.1371/ journal.pone.0045989

Ferreira SM, Pfab M, Knight MH. 2014. Management strategies to curb rhino poaching: an exploration of alternative options. *South African Journal of Science*. Provisionally accepted.

Fougere C. 2006. Customary law and international human rights: The Queen v GJ. *Law Society Journal August* 2006:42.

Hieronymus TL, Witmer LM, Ridgely RC. 2006. Structure of white rhinoceros (*Ceratotherium simum*) horn investigated by X-ray histology with implications computed tomography and for growth and external form. *Journal of Morphology* 267: 1172-1176.

Izzo JB. 2010. PC pets for a price: Combating online and traditional wildlife crime through international harmonization and authoritative policies. *William and Mary Environmental Law and Policy Review* 34: 965-998.

Jain TR. 2006. *Microeconomics and basic mathematics.* VK Publications, New Delhi.

Lindsey PA, Taylor A. 2011. *A study on dehorning of the African rhinoceros as a tool to reduce the risk of poaching.* Department of Environmental Affairs, Pretoria.

Linklater WL, MacDonald EA, Flamand JRB, Czekala NM. 2010. Declining and low fecal corticoids are associated with distress, not acclimation to stress, during the translocation of African rhinoceros. *Animal Conservation* 13:104-111.

Knight M. 2011. African Rhino Specialist Group report: 10th Meeting of the IUCN/SCC African Rhino Specialist Group. *Pachyderm* 49:6-15.

Makeitfrom.com 2009. Compare materials. http://www.makeitfrom.com/compare-materials/?A=Polymethylmethacrylate-PMMA-Acrylic-Plexiglas&B=Soda-Lime-Glass. Accessed 3 March 2014.

Milliken T, Shaw J. 2012. *The South Africa – Viet Nam rhino horn trade nexus: A deadly combination of institutional lapses, corrupt wildlife industry professionals and Asian crime syndicates.* TRAFFIC, Johannesburg.

Natarajan M, Hough M. 2000. *Illegal drug markets: From research to prevention policy.* Lynne Rienner Publishers, Boulder.

Pienaar DJ, Hall-Martin AJ. 1993. Calculating white and black rhinoceros anterior horn mass using horn density and volume. *South African Journal of Wildlife Research* 23: 82-86.

Pienaar DJ, Hall-Martin AJ, Hitchins PM. 1991. Horn growth rates of free-ranging white and black rhinoceros. *Koedoe* 34:97–105.

Rachlow JL, Berger J. 1997. Conservation implications of patterns of horn regeneration in dehorned white rhinos. *Conservation Biology* 11:84–91.

Rhino Rescue Project. 2013. *About the project.* http://www.rhinorescueproject.com/about-the-project/. Accesses 25 April 2013.

Roux DJ, Foxcroft LC. 2011. The development and application of strategic adaptive management within South African National Parks. *Koedoe* 53: 1-5.

Roux DJ, McGeogh MA, Foxcroft LC. 2012. *Assessment of selected in-house research achievements for the period 2008-2011.* Scientific Report 01/2012, SANParks, Skukuza.

Tsang YY, Tang ASP. 2007. Tetrodotoxin poisoning. http://www.cfs.gov.hk/english/multimedia/multimedia_pub/multimedia_pub_fsf_09_01.html. Accessed 3 March 2014.