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Darting Primates: Steps Toward Procedural and Reporting Standards

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Abstract Darting, a common method of capturing wild primates, poses risks to the individuals that must be appropriately minimized. A recent article in the *International Journal of Primatology* by Cunningham *et al.* (*International Journal of Primatology*, 36(5), 894–915, 2015) presented a literature review of the reporting of darting procedures in primatology and anonymously surveyed primatologists on darting methods and their effects, to report general trends in the field. We quantitatively reexamined 29 articles described by the authors as having information on fatalities and/or injuries. We think that the various body masses of primates (1 kg–150 kg), along with their locations and habitat types, and the degree of experience of the darting team, should be considered when estimating mortality and injury rates, and thus preclude the computation of an average mortality value across taxa. Nevertheless, we computed an average (mean) for comparison with the previous analyses. Our mean estimated mortality rate was 2.5% and the mean estimated injury risk was 1.5% ($N = 21$ articles). Thus, our estimated mortality rate is smaller than the combined mortality and injury rate of 5% reported by Cunningham *et al.*

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(*International Journal of Primatology*, 36(5), 894–915, 2015) and smaller than the mortality rates of medium-sized terrestrial mammals they used for comparison. Our study strongly suggests the critical need for more data to be analyzed in a standardized fashion.

Keywords Best practices · Capture · Ethics · Methods · Risk

Introduction

Darting is a common method of capturing primates. Because darting poses risks to the individuals being captured there are specific considerations that are a function of the species size, habitats, and behavior. A recent article in the *International Journal of Primatology* anonymously surveyed primatologists on darting methods and their effects on primates, and conducted a literature review to assess the reporting trends of darting methods and results (Cunningham *et al.* 2015). The authors report that in only 18 of 111 articles (16.2%) documenting darted primates did researchers include what they considered sufficiently detailed darting procedures and they call for more detailed reporting of darting procedures in publications. From the data included in these 18 articles, they estimated that 33 of ca. 654 darting events resulted in serious complications, injuries, or deaths. They consider this estimated 5% rate, which includes both mortality and injuries, “alarming” and compare it to darting protocols that consider mortality rates of large, terrestrial mammals >2% unacceptable.

An assessment of the current state of darting in primatology and the risks associated with it is necessary and welcome. The revising and improvement of capture and darting techniques must be a regular procedure for any primate capture project, as well as for the field of primatology in general. Reducing the injury and mortality risks associated with darting is a basic way of improving the quality of the research; therefore, an evaluation of the published data on darting procedures is an important and necessary step. Increased details on the methodological procedures for darting primates, including information on injuries and fatalities, can only help improve darting methods and reduce the risks.

Our ultimate goal is the same as that of Cunningham *et al.* (2015), to contribute to developing a system in which experienced primatologists can make their knowledge available to others and to develop protocols that substantially reduce direct, indirect, and delayed mortality of immobilized primates. The need for more systematically reported data is illustrated when considering the diversity of the primates we study, the experience of the research team, and the cultural context in which the protocols are implemented. But because of that diversity, we think it is necessary to analyze the published data *per study*, combining data across studies only after considering factors that may make the combination and/or comparison unwarranted.

To illustrate the limitations of existing data, we quantitatively reanalyzed the 29 articles described by Cunningham *et al.* (2015) as having information on fatalities and/or injuries (26% of all articles considered). The objectives were 1) to reanalyze the data contained in the 18 articles classified as having detailed information on injuries, deaths, and procedures; 2) to expand the analyses by incorporating 11 articles classified as including general information on fatalities and procedures; and 3) to propose that a single quantitative estimate of death or injury for all primates is neither informative nor helpful.

Methods

We reanalyzed 29 of the articles considered in Cunningham *et al.* (2015): 18 articles assessed as having detailed information on darting procedures and 11 with information on the rate of fatalities, other health problems, and general information on procedures (Cunningham and colleagues kindly provided us full citations for these 11 articles). These articles were selected by the authors from a set of 111 articles identified through searches and ranked for the level of information on darting procedures, from most comprehensive (1) to no detail (5).

We sought to quantitatively analyze the injuries and mortality reported in the literature, a different objective from that of Cunningham *et al.* (2015), whose stated goal was to examine *reporting* trends in darting. Owing to this difference, we excluded 3 of the 18 articles in Category 1 and 5 of the 11 in Category 2 that may have been appropriate to include in an analysis of reporting trends, but not in an analysis of injuries and mortality. Specifically, we excluded articles in which the health of the darted primates was compromised before darting, as we believe this to be a conflicting factor in analyzing the injury and mortality risk of darting. We excluded for this reason Sleeman *et al.* (2000) and Hyeroba *et al.* (2011). In the first study, 100% ($N = 26$) of the individuals had some form of complication or medical issue before being darted; in the second study, the health situation was the reason for darting this male chimpanzee. We also excluded 5 of the 11 articles in Category 2 in which the reported dartings were the same ones described in an already included article to avoid considering the same data twice. Fernandez-Duque and Erkert (2006) was excluded because the individuals darted are the same ones described in Fernandez-Duque and Rotundo (2003). Kappeler and Erkert (2003), Ostner and Kappeler (1999), Port *et al.* (2009), and Wimmer and Kappeler (2002) report the same captured red-fronted lemurs (*Eulemur fulvus rufus*) as those described in Ostner and Kappeler (2004), 98 individuals captured between 1996 and 2002; we considered only the latter study. Akinyi *et al.* (2013) report captured individuals that belonged to the same population described in Tung *et al.* (2011). We include in our analyses the 101 individuals reported in the latter article.

We summarized the information in the remaining 21 articles as follows. We produced estimates per study first, only then obtained averages (mean) across studies. For each article, we noted the number of individuals darted (when reported) and captured. Although all primates hit with a dart are at risk of darting, only six articles report the number of individuals darted. Because our objective is to quantify the risks of darting as a primate capture technique, we used the number of reported captures in our analyses. To consider the fact that primates are often recaptured, we focus on the number of captures rather than the number of individuals. Thus, a “capture” refers to the event of a primate being physically retrieved after being darted.

We also considered the retrieval methods used after the individual had been darted. The retrieval of immobilized primates was divided into three main categories: 1) fell to ground, 2) caught when falling, or 3) retrieved from tree by a researcher. This is important, because very frequently darted individuals need to be retrieved by shaking branches or climbing the tree and grabbing them. Ignoring this frequent retrieval method can lead to an inaccurate or misleading success rate for capturing darted individuals. In addition, because many of the primates that we study fall naturally without the fall being fatal (Schultz [1937] found that 9% of adult wild great ape

skeletons had healed fractures), we considered that the risk of darting is best assessed by quantifying the number of individuals injured as a result of the actual darting, rather than using falling as a metric for risk. As explained previously, using the number of individuals not caught when falling neglects the number of individuals captured without risk from falling. Fatal injuries that caused the primate to later die were not counted as injuries, but as deaths.

All the information on darting analyzed during the current study was obtained from published articles and is therefore publicly available. All data generated during this study are included in this published article and in the Supplementary Electronic Material (ESM) Table S1.

Results

The 21 articles we considered describe 936 captures and a minimum of 986 darting events. The mean mortality rate was 2.5% (SD = 4.0, $N = 21$ articles, Table 1). Eighteen deaths were reported, 16 of which can be directly attributed to the darting. Of the remaining two, one howler death was caused by ether overdose during handling (Scott *et al.* 1976) and one pregnant female baboon fell ca. 4 m, showed no signs of injury before or after, and was observed 2 days later carrying a dead infant (Melton 1980).

The nonfatal, serious injury rate mean was 1.5% (SD = 3.3, $N = 21$ articles). Eight injuries were reported. In one study 13 individuals required artificial respiration (Scott *et al.* 1976) and three studies described primates having problems with thermoregulation (Glander *et al.* 1991; Hiong *et al.* 1996; Lemos de Sá and Glander 1993). Two of the eight injuries were superficial wounds and described as “slight” (Olupot 1999). Regardless of the severity of the injury, all injured individuals were reported to have made a full recovery.

The percentage of injuries and deaths varied considerably (range: 0–14%) among the 15 articles providing detailed information (Table 1, Category 1 of Cunningham *et al.* 2015). Serious injuries occurred in $2.0 \pm 3.8\%$ (mode: 0) of the capturing events and deaths in $3.3 \pm 4.5\%$ (mode: 0) of them. These articles describe 592 captures and at least 642 dartings; 9 articles (60%) do not report the number of unsuccessful dartings, i.e., “misses.” Seven of the 15 articles (47%) provide precise numbers on how immobilized individuals were physically retrieved.

Five of the six articles (83%) providing general information (Category 2 of Cunningham *et al.* 2015) reported no injuries or deaths, and the remaining reported 4.6% of deaths and no information on injuries. These 6 articles describe 344 captures. They provide fewer details on darting procedures and do not include the number of individuals darted.

Discussion

We estimated a mean mortality rate of 2.5% and a nonfatal, serious injury rate of 1.5%. Thus, our estimated mortality rate is smaller than the combined mortality and injury rate of 5% reported by Cunningham *et al.* (2015) and smaller than the mortality rates of medium-sized terrestrial mammals used for comparison. Arnemo *et al.* (2006) report

Table I Summary of the darting methods and results in the analyzed studies

Study	Darted (hits)	Captured	No. of injuries	No. of deaths	% Injuries	% Deaths
Scott <i>et al.</i> (1976)	N/A	152	0	3 (2 due to darting)	0	1
Melton (1980)	51	34	1	2 (1 due to darting)	3	3
Jones and Bush (1988)	48	27	2	2	7	7
Glander <i>et al.</i> (1991)	N/A	64	0	1	0	2
Richard <i>et al.</i> (1991)	N/A	85	0	1	0	1
de Ruiter (1992)	N/A	7	0	0	0	0
Lemos de Sá and Glander (1993)	N/A	12	0	0	0	0
Campbell and Sussman (1994)	8	7	0	1	0	14
Mueller and Schildger (1994)	N/A	5	0	0	0	0
Hiong <i>et al.</i> (1996)	N/A	50	0	2	0	4
Glenn <i>et al.</i> (1998)	8	5	0	0	0	0
Karesh <i>et al.</i> (1998)	11	9	1	1	11	11
Olupot (1999)	47	41	2	2	0	5
Fernandez-Duque and Rotundo (2003)	N/A	70	0	0	0	0
Crofoot <i>et al.</i> (2009)	N/A	24	2	0	8	0
Horwich (2002)	N/A	65	N/A	3	N/A	5
Ostner and Kappeler (2004)	N/A	98	0	0	0	0
Erkert and Kappeler (2004)	N/A	8	0	0	0	0
Andriantompohavana <i>et al.</i> (2004)	N/A	44	0	0	0	0
Donati <i>et al.</i> (2009)	N/A	28	0	0	0	0
Tung <i>et al.</i> (2011)	N/A	101	0	0	0	0
Total	986	936	8 (6 serious)	18 (16 due to darting)	1.5 (SD = 3.3)	2.5 (SD = 4.0)

The full, detailed table is available as Supplementary Electronic Information (Table SI)

mortality rates <2% only for large terrestrial mammals (moose, 0.7%; bears, 0.9%) and >2% for medium-sized ones (2.8%, wolverines, 3.9% Eurasian lynx, 3.4% gray wolves, Table I). Based on these results, these authors suggest “that wildlife professionals should strive for a zero mortality rate but adopt the standard that a mortality rate of > 2% probably should not be accepted in any **large** [our emphasis] mammalian species” (p. 109). We agree with Cunningham *et al.* (2015) that primate researchers should strive for the lowest mortality rate possible, but we consider our estimates and theirs, when comparing across species, to be of little value and quite possibly

misleading. Furthermore, these numbers can be potentially damaging when used in the wrong context.

Comparing statistics and methods across species can be useful and the sharing of information among researchers who study different species should be encouraged. However, although comparing models and statistics can be valuable, one needs to acknowledge and consider the differences between taxa, geographic regions, and research teams when developing taxon-specific protocols. Most primates are fairly small, arboreal animals, and therefore darting primates will unequivocally be different than darting large, terrestrial mammals. We propose that the first step should be to consolidate existing experience darting primates, which is extensive and spans all continents and a wide range of taxa (Fernandez-Duque and Rotundo 2003; Fernandez-Duque *et al.* 2000; Juárez *et al.* 2010; Glander 2013; Glander *et al.* 1991; Serio-Silva *et al.* 2015; Wasserman *et al.* 2013).

We did not delve into the ethics of darting, but rather evaluated it as a capture procedure. At this point, there are simply not enough details on darting to estimate accurately the risk that darting poses to primates. Therefore, we join Cunningham *et al.* (2015) and previous authors (Fedigan 2010) in calling for detailed descriptions of darting procedures and results. We encourage colleagues to include information on darting procedures, and for journals not only to allow, but also to encourage its inclusion. As seen in Sleeman *et al.* (2000) and Hyeroba *et al.* (2011), it will be increasingly necessary to capture primates to protect them from human activities, such as snaring. This will become increasingly difficult if experts do not provide detailed information on darting procedures, risks, and outcomes. Ultimately, and hopefully, greater communication and sharing of information among researchers will help mitigate any potential effects of our research on the well-being of primates.

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