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State of Knowledge of Wildlife Responses to Remotely Piloted Aircraft Systems (RPAS)

Scientific Committee on Antarctic Research (SCAR)

SUMMARY

The increasing use and utility of Unmanned Aerial Vehicles (UAVs), which are now preferably known as Remotely Piloted Aircraft Systems (RPAS), across the globe, including in Antarctic, brings corresponding challenges to their management. The Antarctic Treaty System's Committee for Environmental Protection (CEP) has recognised on several occasions the need for more information to inform guidelines on RPAS use around wildlife in Antarctica, including a request for the Scientific Committee for Antarctic Research (SCAR) to present a summary of the current state of knowledge regarding wildlife responses to RPAS. Here we present a synthesis from 23 published scientific research papers on wildlife responses to RPAS. Responses to RPAS were not consistent across species, and responses also varied in relation to flight path parameters (e.g. height and approach angle) and the type of RPAS. It is likely that wildlife responses are under-estimated in many cases due to a lack of data on physiological responses. Data on demographic effects (for example, changes in breeding numbers or breeding success) are also lacking. Guidelines for minimising RPAS disturbance to wildlife have been developed (see Hodgson and Koh 2016 [1] Annex 1) and should be considered in biological field research. Further studies are required to inform best-practice RPAS use in Antarctica around wildlife.

RECOMMENDATIONS

1. SCAR recommends that the Working Group considers the following preliminary best practice guidelines for all RPAS use in the vicinity of wildlife:
    a. Take-off should be further than 100 m from wildlife and if possible, out of sight of the target species. Horizontal approaches to wildlife are preferable and RPAS should be flown at the maximum height practicable to achieve the study objectives.
    b. Electric powered RPAS should be used where possible to minimise noise impacts.
    c. The recommendations of Hodgson and Koh (2016) ([1]], Annex 1) should be consulted and adhered to or exceeded wherever possible.

2. SCAR further recommends that future studies on wildlife response to RPAS should consider:
    a. Both behavioural and physiological responses.
    b. Demographic effects.
    c. Ambient environmental conditions.
    d. RPAS of different sizes and specifications
    e. RPAS noise and wildlife disturbance.
    f. Control sites.
    g. Habituation effects.

Estado actual de los conocimientos sobre las respuestas de la vida silvestre a los Sistemas de Aeronaves Dirigidas por Control Remoto (RPAS)

RESUMEN

El uso y la utilidad en aumento de los vehículos aéreos no tripulados (VANT), que actualmente se conocen en todo el mundo, incluso en la Antártida, como Sistemas de Aeronaves Dirigidas por Control Remoto (RPAS), conllevan los correspondientes desafíos a su gestión. El Comité para la Protección del Medio Ambiente (CPA) del Sistema del Tratado Antártico ha reconocido en reiteradas ocasiones la necesidad de obtener más información que sirva de base para definir pautas sobre el uso de RPAS en torno a la vida silvestre en la Antártida, incluida una solicitud formulada al Comité Científico de Investigaciones Antárticas (SCAR) para que presentara un resumen del estado actual de los conocimientos en relación con las respuestas de la vida silvestre a los RPAS. En este documento, se presenta una síntesis de 23 documentos publicados sobre investigaciones científicas relativas a las respuestas de la vida silvestre a los RPAS. Estas respuestas no fueron homogéneas entre las distintas especies y, además, fueron variadas en relación con los parámetros relativos a la trayectoria de vuelo (por ejemplo, altura y ángulo de aproximación) y el tipo de RPAS. Es probable que, debido a la falta de datos sobre las respuestas fisiológicas, se subestimen en muchos casos las respuestas de la vida silvestre. También son insuficientes los datos sobre los efectos demográficos (por ejemplo, cambios en las cifras de ejemplares reproductores o en el éxito reproductivo). Se elaboraron pautas para reducir al mínimo la perturbación de la vida silvestre generada por el uso de RPAS (ver Hodgson y Koh 2016 [1] Anexo 1), las cuales deberían tenerse en cuenta en la investigación biológica de campo. Se requieren más estudios que sirvan de base para la elaboración de mejores prácticas sobre el uso de RPAS en torno a la vida silvestre en la Antártida.

RECOMENDACIONES

1. El SCAR recomienda que el Grupo de Trabajo considere las siguientes guías de mejores prácticas preliminares para cualquier uso que se haga de los RPAS en las proximidades de la vida silvestre:

   a. Los despegues deben llevarse a cabo a más de 100 m de distancia de la vida silvestre y, si fuera posible, fuera del campo visual de las especies objetivo. Son preferibles las aproximaciones horizontales a la vida silvestre, y los RPAS deben volar a la máxima altura que resulte factible para el cumplimiento de los objetivos del estudio.

   b. En la medida de lo posible, deben utilizarse RPAS eléctricos a fin de reducir al mínimo su impacto sonoro.

   c. Deben consultarse, adoptarse o superarse las recomendaciones formuladas por Hodgson y Koh (2016) ([1], Anexo 1) siempre que sea posible.

2. El SCAR recomienda además que los futuros estudios sobre las respuestas de la vida silvestre a los RPAS consideren lo siguiente:

   a. Las respuestas tanto fisiológicas como comportamentales.

   b. Los efectos demográficos.

   c. Las condiciones medioambientales del ambiente.

   d. Los diferentes tamaños y especificaciones de los RPAS.

   e. El ruido generado por los RPAS y su grado de perturbación de la vida silvestre.

   f. Los sitios de control.

   g. Los efectos del acostumbramiento.

État des connaissances sur les réactions de la faune sauvage dues à la présence d'aéronefs pilotés à distance (RPA)

RÉSUMÉ

L'utilisation croissante des aéronefs sans pilotes (UAV), qu'il est recommandé d'appeler aéronefs pilotés à distance (RPA), dans le monde, y compris en Antarctique, représente de sérieux défis de gestion. À plusieurs reprises, le Comité pour la protection de l'environnement (CPE) du Système du Traité sur l'Antarctique a reconnu qu'il était nécessaire de collecter de plus amples informations afin d'alimenter les lignes directrices relatives à l'utilisation des RPA à proximité de la faune sauvage en Antarctique. Ainsi, une demande a été faite au Comité scientifique pour la recherche antarctique (SCAR) afin qu'il présente un résumé de l'état actuel des connaissances sur les réactions de la vie sauvage provoquées par la présence de RPA. Le document offre une synthèse des 23 articles scientifiques publiés sur les réactions de la faune sauvage dues à la présence de RPA. Notons que les réactions de la faune sauvage ne sont pas homogènes entre les espèces,

et varient également selon les paramètres de trajectoire de vol (ex. : hauteur et angle d'approche) et le type de drone (RPA) utilisé. Il est probable que les réactions de la faune sauvage soient souvent sous-estimées en raison du manque de données relatives aux réponses physiologiques des animaux. Les données manquent également concernant les effets démographiques (par exemple, des modifications du nombre de couples reproducteurs ou une variation du taux de reproduction). Des lignes directrices destinées à minimiser les perturbations de la faune sauvage ont été élaborées (voir Hodgson et Koh 2016 [1] Annexe 1) et devraient être prises en compte dans la recherche biologique sur le terrain. Il est nécessaire de mener d'autres études afin de définir les bonnes pratiques d'utilisation des RPA à proximité de la faune sauvage en Antarctique.

RECOMMANDATIONS

1. Le SCAR recommande que le Groupe de travail examine les lignes directrices provisoires relatives aux bonnes pratiques d'utilisation de tous les RPA à proximité de la vie sauvage :
   a. Le décollage doit s'effectuer à plus de 100 m de la faune sauvage, et si possible hors de la vue des espèces ciblées ; l'approche horizontale en direction de la faune sauvage est conseillée et la hauteur de vol du RPA doit être la plus haute possible tout enpermettant d'atteindre les objectifs de l'étude.
   b. Les RPA à alimentation électrique sont à privilégier de sorte à réduire au mieux les perturbations sonores.
   c. Les recommandations de Hodgson et Koh (2016) ([1]], Annexe 1) doivent être consultées, appliquées et/ou dépassées dans la mesure du possible.
2. En outre, le SCAR recommande que les études à venir sur les réactions de la faune sauvage dues à la présence de RPA se penchent sur :
   a. Les réactions à la fois physiologiques et comportementales.
   b. Les répercussions démographiques.
   c. Les conditions environnementales ambiantes.
   d. Les différents types et caractéristiques de RPA.
   e. Les perturbations sonores des RPA et leurs effets sur la faune sauvage.
   f. Les sites de référence.
   g. Les effets d'accoutumance.

1. INTRODUCTION

Unmanned aerial vehicles (UAVs), also known as unmanned aerial systems (UAS), drones, or Remotely Piloted Aircraft Systems (RPAS), are increasingly used in wildlife research around the world (including Antarctica) due to their efficiency, cost effectiveness and accuracy [2,3,4].

In Antarctica, RPAS have been used for population monitoring [5,6,7], fine scale vegetation mapping [8], determining ecosystem function [9], operational applications [10,11] and during tourist activities (with permits [12])

Applications of RPAS in other parts of the world are even more diverse. Environmentally related applications include: monitoring habitat and biodiversity loss [13], biodiversity assessment [14], population monitoring [15,16,17,18), fine scale habitat assessment [19], locating tracked wildlife [20], as an anti-poaching measure [21] and vegetation monitoring [22].

Concomitant with this increasing use is an increasing awareness of the potential impacts, both from an operational and wildlife disturbance perspective [1, 7].

At ATCM XXXVII (2014) discussions on the use of RPAS in Antarctica culminated in a request to COMNAP, SCAR and IAATO to consider the issue of wildlife responses to RPAS and bring back information which explored the utility and risks of RPAS operation in Antarctica.

In ATCMXXXVIII WP27, SCAR presented results of a meta-analysis of wildlife approach distances (see also [23]), and concluded that:

a. There was no one-size-fits-all approach to managing human disturbance effects on wildlife. Management guidelines for different sites and species need to be developed on a case-by-case basis, ideally in conjunction with carefully designed experiments.

b. Animal behavioural changes do not necessarily reflect cryptic (physiological), and more deleterious impacts, such as changes in physiology, or long-term changes in population trends.

c. The scientific evidence base for limiting human disturbance impacts to Antarctic wildlife is inadequate, and is in urgent need of improvement via a range of dedicated studies on RPAS, and other disturbances across a range of sites and species.

In its subsequent advice to ATCM XXXVIII (2015), the CEP recognised the benefits of developing guidance on the environmental aspects of RPAS use in Antarctica. Following submission of further information to CEP XIX in 2016 on RPAS use in Antarctica from Germany (ATCMXXXIX WP01- see also [7]), Poland (ATCMXXXIX IP057 – see also [24]), COMNAP (ATCMXXXIX WP014 [11]) and IAATO (ATCMXXXIX IP120 [12]), the CEP provided similar advice to the ATCM and agreed to initiate work in this respect at CEP XX in 2017.

Following the discussions at CEP XVIII, SCAR agreed to report back to the CEP in 2017 on the current state of knowledge of wildlife responses to RPAS. Following this submission, the CEP thanked SCAR for the comprehensive report on the state of knowledge of wildlife responses to RPAS use in the Antarctic. The CEP acknowledged the value of the precautionary best-practice guidelines for RPAS use in the vicinity of wildlife in Antarctica, and agreed to encourage the dissemination and use of those guidelines as an interim measure pending the further development of broader guidance on the environmental aspects of RPAS use in Antarctica.

2. APPROACH

Literature searches were made using a range of search terms covering all RPAS nomenclature using Google Scholar, Web of Science, reference mining and citation tracking from key references. National Guidelines on RPAS use were also requested from SCAR Delegates, National Antarctic Committees and COMNAP.

Studies were included in the assessment if they i) were published in peer reviewed literature, ii) included RPAS use around wildlife that was not captive, semi-captive or domesticated, and iii) included some form of monitoring of wildlife response to RPAS (even if it was incidental).

Summaries of the findings of these studies were compiled based on target species, RPAS type, behavioural response and flight path details Annex 2). A full list of references is provided in Annex 3.

3. FINDINGS

Twenty-three published studies were included in the assessment. Of these, 12 documented a change in wildlife behaviour in response to RPAS. All studies used behavioural change as a measure of response, but only one [26] quantified physiological changes to measure the level of response to RPAS.

Measurement of behavioural change ranged from observational (no recording, qualitative assessment of change) to experimental, where video recording was used with a quantifiable scale of behaviour change.

Responses to RPAS were not consistent across species, and responses also varied in relation to flight path parameters (e.g. height and approach angle [7,26] and the type of RPAS [24,27]. However, most studies that reported a response, found that lower RPAS flights elicited a stronger response. Vertical approaches to birds typically elicited more responses than horizontal or angled approaches [7,26].

Launching RPASs no closer than 100 m to bird colonies has been recommended [26], and supported by preliminary data on Antarctic penguins [7].

Noise of RPAS can be detected from large distances, and the ability to detect RPAS varies considerably among species [28]. Noise was identified in several studies as an important factor of interest in eliciting responses [6,7,24,29] and there is some evidence that electric powered fixed wing RPAS elicited less response than wet-fuel powered RPAS at the same altitude [24].

Preliminary evidence suggests that group size influences response [26,27] and that animals at different stages of the breeding cycle show different responses [30].

Physiological responses, for example heart rate, are a good indicator of acute and/or chronic stress in wildlife [23,31]. A variety of methods have been used successfully to measure the physiological responses of wildlife to disturbance in the Antarctic region. These include heart rate measurements using artificial eggs (e.g. [32,33,34]) or externally-mounted/implanted data loggers (e.g. [35,36]). Monitoring changes in blood chemistry can also provide important insights into stress responses (e.g. [37,38]).

4. CONCLUSIONS

Use of RPAS around wildlife is increasing in Antarctica, and considering the similar increase observed globally, their use in Antarctica will not only continue to increase but also expand in their application.

Consistent with previous SCAR recommendations, this review supports the conclusion that there will not be a one-size-fits-all solution to the mitigation of wildlife responses to RPAS. Guidelines will clearly need to be site- and species-specific and consider the type of RPAS used, including noise output.

Given that physiological responses (indicative of a stress) can occur without any sign of behavioural responses (e.g. [25]), further studies that include the physiological response of wildlife to RPAS are needed. Data on demographic changes in response to RPAS use are also lacking and more studies are required.

ANNEX 1

Hodgson JC & Koh LP (2016) Best practice for minimising unmanned aerial vehicle disturbance to wildlife in biological field research. *Current Biology* **26**:R404-R405.

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ANNEX 2

Summary of peer reviewed published papers that monitored responses of wildlife to Remotely Piloted Aircraft Systems (RPAS)

Reference	Journal	Species	RPAS type	Disturbance study?	Vertical Heights (m)	Were responses to sound observed?	Were behavioural responses observed?	Were physiological responses observed ?
Antarctic region								
Rümmler et al. (2016) [7]	Polar Biology	Adélie penguins	Octocopter	Yes	10-50	NA	Yes	NA
Goebel et al. (2015) [6]	Polar Biology	Chinstrap penguins Gentoo penguins, Fur seals	Hexacopter	No	23-60	No (but compared with ambient)	No	NA
Korczak-Abshire et al. (2016) [24]	CCAMLR Science	Adélie penguins, Southern giant petrels	Fixed wing	Yes	350	NA	Yes	NA
Ratcliffe et al. (2015) [40]	Journal of Unmanned Vehicle Systems (JUVS)	Gentoo penguins	Hexacopter	No	30	NA	Yes	NA
Global								
Ditmer et al. (2015) [25]	Current Biology	Bears	Quadcopter	Yes	20	Yes	Yes	Yes
Vas et al. (2015) [26]	Biology Letters	Greenshanks, Flamingos.	Quadcopter	Yes	4-30	NA	Yes	NA
McEvoy et al. (2016) [27]	JPress	Mixed waterbirds	Multirotor, fixed wing	Yes	40-120	NA	Yes	NA
Smith et al. (2016) [41]	JUVS	Marine mammals	Multirotor, fixed wing	Yes	5-300 +	Yes	Yes	NA

Sarda-Palomera et al. (2012) [16]	Ibis	Gulls	Fixed wing	No	30-40	NA	No	NA
Grenzdörffer (2013) [42]	Book chapter	Gulls	Multirotor	No	15	NA	No	NA
Weissensteiner et al. (2015) [43]	Journal of Avian Biology	Canopy nesting birds	Quadcopter	No	5	NA	Yes	NA
Chabot et al. (2015) [39]	PLoS One	Terns	Fixed wing	No	90-122	NA	Yes	NA
Chabot and Bird (2012) [15]	Waterbirds	Geese	Fixed wing	No	30-40	NA	No	NA
Pomeroy et al. (2015) [30]	JUVS	Grey seals	Multirotor	No	40-250	NA	Yes	NA
Durban et al. (2015) [44]	JUVS	Killer whales	Hexacopter	No	35-40	NA	No	NA
Duvala et al. (2015) [45]	Environmental Practice	Mixed waterbirds	Fixed wing, gas powered	No	15-146	NA	Yes	NA
Moreland et al. (2015) [29]	JUVS	Ribbon and spotted seals	Fixed wing	No	122	NA	Yes	NA
Koski et al. (2015) [46]	JUVS	Bowhead whales	Mini-copter	No	120	NA	No	NA
Acevedo-Whitehouse et al. (2010) [47]	Animal Conservation	Whales	RC Helicopter	No	13	NA	No	NA
Vermeulen et al. (2013) [17]	PLoS One	Elephant	Fixed wing	No	100	NA	No	NA
Mulero-Pázmány et al. (2014) [21]	PLoS One	Rhino	FW	No	100-180	NA	No	NA
Jones et al. (2006) [48]	Wildlife Society Bulletin	Manatee	FW	No	100-150	NA	No	NA
Hodgson et al. 2016 [18]	Scientific Reports	Frigate birds, Crested terns, Royal penguins	Multirotor, fixed wing	No	75-120	NA	No	NA

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