

The effects of COVID-19 litter on animal life

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Abstract

During the COVID-19 pandemic, Personal Protective Equipment (PPE) is massively used, resulting in a new wave of litter: protective face masks and gloves. Here we present the first case of a fish entrapped in a medical glove, encountered during a canal clean-up in Leiden, The Netherlands. We also report the first cases of birds using medical face masks as nesting material, which were also found in the Dutch canals. To place these new findings in context, we collected online reported interactions of animals with PPE litter, since the start of the pandemic. This resulted in the first overview of cases of entanglement, entrapment and ingestion of COVID-19 litter by animals and the use of it as nesting material. We signal COVID-19 litter as a new threat to animal life as the materials designed to keep us safe are actually harming animals around us. To understand the full scale of this problem, we welcome anyone to contribute to our overview by submitting their observations online at www.covidlitter.com. To further prevent PPE litter, it is recommended that, when possible, reusable alternatives are used.

Keywords

Bird nest; entanglement; entrapment; face mask; plastic pollution; PPE

Introduction

After the outbreak of the COVID-19 virus was first identified in Wuhan, China, in December 2019, the World Health Organization officially declared the virus a pandemic on 11 March 2020 (WHO, 2020). During the past months the pandemic has resulted in almost 90 million confirmed cases and almost two million deaths

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globally as of early January 2021 (JHUM, 2020). While we have seen reductions in air pollution (Chen et al., 2020; Dutheil et al., 2020), NO₂ emissions (NASA, 2020), and CO₂ emissions (Myllyvirta, 2020), plastic pollution seems to be increasing (Fadare & Okoffo, 2020; Silva et al., 2021). To protect humans against this virus, personal protective equipment (PPE) is being used more frequently. China, for example, increased face mask production by 450% in just one month (Bown, 2020). It is estimated that we have a monthly use of 129 billion face masks and 65 billion gloves globally (Prata et al., 2020). Similar to the usage of other single-use plastic items, this also means an increase of PPE littering our environment (Fadare & Okoffo, 2020). PPE litter, also referred to as COVID-19 litter, mainly consists of single-use (usually latex) gloves and single-use face masks, consisting of rubber strings and mostly polypropylene fabric. Three months after face masks became obligatory in the UK, PPE items were found on 30% of the monitored beaches and at 69% of inland clean-ups by the citizen scientists of the Great British Beach Clean (Riglen, 2020). Even on the uninhabited Soko Islands, Hong Kong, already 70 discarded face masks were found on just a 100-meter stretch of beach (Kassam, 2020). A growing public concern about PPE litter became apparent during March and April 2020, as a Google News search on ‘PPE’ and ‘litter’ showed a sudden increase in news articles (Canning-Clode et al., 2020). As a response to the increase of COVID-19 litter, many states in the USA have raised the fines for littering PPE, sometimes up to \$5500 as in Massachusetts (O’Laughlin, 2020).

The #glovechallenge, in which people shared their observations of gloves and face masks (fig. 1), resulted in more than 11 000 photos of COVID-19 litter from all over the world (Cardona, 2020). A Dutch COVID-19 litter project reported 6347 photos of gloves or face masks littering The Netherlands during the months of May and June (Groot, 2020). Initially, these products were mainly found in close vicinity to supermarkets and healthcare institutions, but when face masks became compulsory in public transport, they were also increasingly being found near bus, tram, and train stations. By now the use of face masks is mandatory or highly recommended in many countries (Sylva et al., 2020). As a consequence, the increase in production and consumption of PPE litter inevitably leads to interaction with animal life.

While the percentage of COVID-19-related litter may be small in comparison with packaging litter (Groot, 2020), it can be seen as a typical example of our single-use society. Both masks and gloves pose a risk of entanglement, entrapment and ingestion, which are some of the main environmental impacts of plastic pollution (Ryan, 2018; Kuhn & van Franeker, 2020). Plastic can have enormous impacts on animals, some direct, others indirectly. An entanglement, for example, can be acute, resulting in immediate death by suffocation or drowning, or chronic, meaning it may exhaust the animal, restrict feeding to the point of starvation or result in strangulations, wounds, infections or cause amputations (Butterworth et al., 2012). Face masks littering the environment could also be an emerging new source of microplastics (Fadare & Okoffo, 2020), but the masks already cause harm prior to degrading. The Iranian cartoonist Alireza Pakdel drew a predictive cartoon

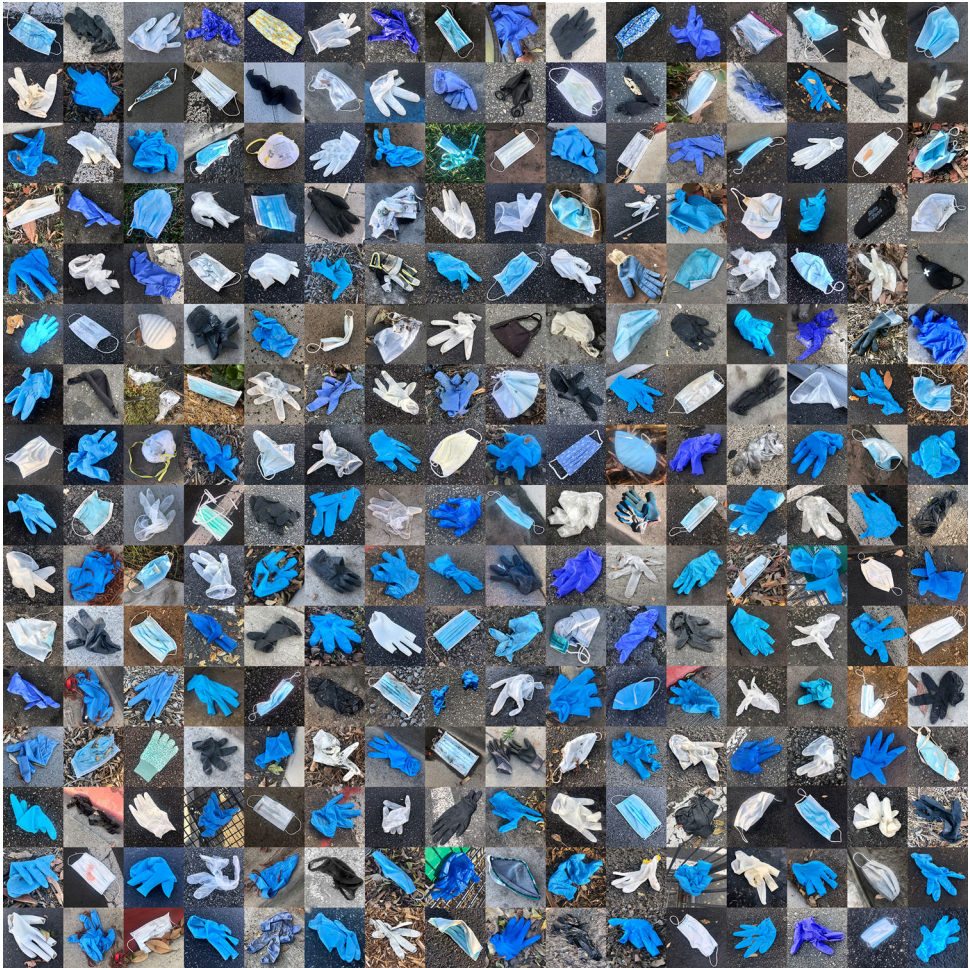


Figure 1. Compilation of 256 images of PPE litter from Vista, CA, USA. Photograph by Janis Selby Jones.

regarding the effects of COVID-19 litter at the start of the pandemic, showing a fish entangled in a face mask facing another fish entrapped in a glove (Pakdel, 2020). Such situations have by now been found in real life – and are presented here. This is the first overview of case studies of the increasing threat of entrapment, entanglement, ingestion of PPE and its inclusion as nesting material by birds.

Methods

Volunteers participating in the Plastic Spotter canal clean-ups collect floating litter using canoes in Leiden, The Netherlands (Rambonnet et al., 2020). Their encounter of a fish entrapped in a latex glove sparked our interest, which was fueled further by the find of face masks and gloves in bird nests. To place these observations into

context we collected all observations of interactions of animal life with COVID-19 litter reported online since the start of the pandemic. For this, we used both Google web search and Google image search, as a method to rapidly collect sightings (Leighton et al., 2016). Search terms that were used, in combination, are: ‘litter’, ‘waste’, ‘PPE’, ‘COVID’, ‘COVID-19’, ‘corona’, ‘face mask’, ‘glove’, ‘entanglement’, ‘entangled’, ‘entrapment’, ‘entrapped’, ‘ingestion’, ‘ingested’, ‘bird nest’; both in English and in Dutch. These search terms, used as hashtags, were also used to explore social media platforms Twitter, Facebook and Instagram for observations. If supporting information on the observation was lacking in the articles and posts we found, we traced back the origins of the photos and articles, using reverse image search or by searching the names of the observer, to collect any further information on the locality, date, observer, and any other details. When these details could not be found online, we tried to contact the observers and reporters when possible.

Presentation of the concerns

The first case of the impact of COVID-19 litter discussed here originates from Leiden, The Netherlands. Already two weeks after the first Dutch case of COVID-19, a face mask was found as litter in the Leiden canals (pers. obs.). Since then, each weekly canal clean-up resulted in multiple face masks and gloves, sometimes over 100 items. At the time of writing, so far many hundreds of face masks and gloves have been found, and counting.

It is known that riverine ecosystems are directly affected by plastic pollution (van Emmerik & Schwarz, 2020). The canals of Leiden harbor not only hotspots of plastic (Tasseron et al., 2020), but also 22 species of fish (van Aarsen, 2018; Verkade, 2018), some of which are protected by national laws and European regulations (MEZ, 2015; MLNV, n.d.). The first evidence that freshwater fish suffer from the recent wave of PPE litter is presented here, with the find of a dead perch (*Perca fluviatilis*) entrapped in a latex glove, with only its tail sticking out (fig. 2). The fish was found in the Oude Vest, Leiden, by citizen scientists during a Plastic Spotter canal clean-up on the 2nd of August 2020, making it the first victim of COVID-19 litter from The Netherlands. The glove was partially ruptured around the base of the thumb, where the fish was entrapped, which could be the result of a struggle. The spiny dorsal fins might have prevented a backward exit. When found, the glove was partly inside-out, meaning that it had been worn before being discarded. As the glove could potentially be contaminated with the COVID-19 virus, precautions were taken by the volunteers during the handling of the specimen and the PPE litter it was entrapped in. The perch, still in its glove, is stored in ethanol as part of ‘De Grachtwacht’ collection located in Leiden, The Netherlands (GW9899-1E). Two years previously, the first fish entrapped in a glove near Tossa de Mar, Spain, was a widely shared news story (Regen, 2018). The polyethylene glove, meant for food preparation, became a classic example of the negative effects of plastic in our oceans. The newly found perch entrapped in a medical latex glove, however, shows



Figure 2. An entrapped perch (*Perca fluviatilis*) in a PPE glove (GW9899-1E), found during a Plastic Spotter clean-up in the canals of Leiden, The Netherlands. Photograph by Auke-Florian Hiemstra.

that plastic litter also impacts the lesser-studied freshwater ecosystems and that the new wave of PPE latex gloves littering our environment could make entrapments like these more frequent in the future.

However, interactions with COVID-19 litter are not always directly negative, as the use of plastic in nest construction is becoming more common (Jagiello et al., 2019). Birds now have also started to include COVID-19 litter into their nests. To our knowledge, we here present the first cases of the incorporation of medical face masks into bird nests. This behavior was firstly seen by a common coot (*Fulica atra*), a species known for its anthropogenic nests (Hiemstra et al., *subm.*), breeding on the Keizersgracht, Amsterdam, The Netherlands on the 3rd of June 2020 (*pers. obs.*). This face mask was later preserved in the Grachtwacht collection (GW9792-2). A nest made by common coots near the Beestenmarkt, Leiden, The Netherlands, showed both a medical face mask and a latex glove, and was collected on the 6th of September 2020 (*pers. obs.*; GW9792-3 and GW9792-4) (*fig. 3*). Gloves were also used as nesting material by sparrows (*Passer sp.*) in a residential area in Warsaw, Poland (Szulkin, 2020). Even packaging of pocket tissues was incorporated into coot nests in spring 2020 (*pers. obs.*; GW9792-5). Since sniffing is a symptom of COVID-19, this unlikely nest item may be pandemic-related as well.



Figure 3. Nest of common coot (*Fulica atra*) partly built with face mask (GW9792-3) and glove (GW9792-4). Nest located at the Beestenmarkt, Leiden, The Netherlands, collected on the 6th of September 2020. Photograph by Auke-Florian Hiemstra.

Our observations may have been the first Dutch cases, yet the first reported victim of COVID-19 litter globally, to our knowledge, was an American robin (*Turdus migratorius*; Denisuk, 2020). This bird appears to have died after becoming entangled in a face mask at Chilliwack, BC, Canada, on the 10th of April 2020 (pers. comm. Sandra Denisuk; fig. 4). After that, a young gull (*Larus* sp.) was found walking with a face mask tangled around its legs in Chelmsford, Essex, UK (RSPCA Essex South, 2020). It had struggled with the mask for two weeks and its limbs and



Figure 4. First victim of COVID-19 litter, an American robin (*Turdus migratorius*) entangled in a face mask at Chilliwack, BC, Canada on the 10th of April 2020. Photograph by Sandra Denisuk.

joints were swollen, but it recovered in the South Essex Wildlife Hospital. A juvenile peregrine falcon (*Falco peregrinus*) on the Yorkshire coast, UK, with its talons entangled in a face mask, eventually managed to free itself (BBC, 2020a). Cygnets from a mute swan (*Cygnus olor*) from Lake Bracciano, near Rome, Italy, were observed with face masks around their beak (wwitaly, 2020), and a mallard (*Anas platyrhynchos*) with a mask hanging around its neck, seen in Casentino, Italy, was referred to by local media as “The duck unable to take off the mask” (ArezzoNotizie, 2020). A recent find of a dead gull in Rotterdam, The Netherlands, which was hit by a car, also had a face mask entangled around its legs. Although this entanglement may not have been the cause of death, it may have weakened the bird as a chronic entanglement, prior to the car-collision (Kompanje, 2021). The bird, together with its face mask, has been preserved in the Natural History Museum of Rotterdam (NMR 9989-172803).

However, not only birds are affected by face masks. While bats already suffer from roost destruction because they have been associated with the start of the COVID-19 outbreak (Shereen et al., 2020; Rocha et al., 2020), they also face the risk of entanglement in PPE litter. A serotine bat (*Eptesicus serotinus*) was found in Nijmegen, The Netherlands, entangled in two face masks (van Otterlo, 2020). A red fox (*Vulpes vulpes*), entangled in a face mask, and a European hedgehog (*Erinaceus europaeus*), entangled in a glove, were reported in the UK (BBC Breakfast, 2020). A hedgehog entangled in a face mask was found in The Netherlands (Egelopvang het Stekeltje, 2020). Also, a checkered pufferfish (*Sphoeroides testudineus*), entangled in a face mask, was found dead during a clean-up at Pace Picnic Island, west of Miami Beach, USA (Clean this beach up, 2020). Two shore crabs (*Carcinus maenas*) were encountered in lake Étang de Berre, France, of which one was found deadly entangled in a face mask, while another entangled crab was walking around with a face mask (Opération Mer Propre, 2020a). A common octopus (*Octopus vulgaris*) in the sea near Cannes, France, was filmed hiding under a face mask. “Even the octopus protects himself against Covid 19” was the description below the video on YouTube (Opération Mer Propre, 2020b; CGTN, 2021).

COVID-19 litter is also ingested by animals, as the find of a Magellanic penguin (*Spheniscus magellanicus*) in Brazil illustrates (Penza, 2020). The stomach of this animal, found on Juquehy Beach in São Sebastião, north of São Paulo, revealed an ingested face mask. Multiple long-tailed macaques (*Macaca fascicularis*) were seen chewing on a face mask in Genting Sempah, Malaysia (Getty Images, 2020). Young gulls (Laridae sp.) have also been observed fighting over a face mask on Weymouth beach, UK, as they were hunting for food, and one flying away with it in its beak (Klein, 2020). Young gulls carrying a face mask were also observed at the port of Dover, and at the coast of Weston-super-Mare in the UK (Reuters, 2020; Simmons, 2020). Ingestions of COVID-19 litter have also been seen in several domestic animals like a cat (*Felis catus*) (ACCT Philly, 2020) and four dogs (*Canis lupus familiaris*) (Defina, 2020; Kaur, 2020; University of Glasgow, 2020; van Gerwen, 2021). Even a six-year-old child ingested parts of a presumed blue face

mask, accidentally baked into a McDonalds chicken nugget (BBC, 2020b). All the above interactions of animals with PPE litter can be found summarized in table 1.

Conclusions

This is the first overview of reported cases of entanglement, entrapment, ingestion, and the use of COVID-19 litter as nesting material. Although the actual number of cases will be much higher than the number of cases found (Laist, 1997) we already signal COVID-19 litter as an emerging threat to animals. PPE litter has already been found in terrestrial, freshwater and marine ecosystems. Also, its impact is observed in all of these habitats, by both vertebrates and invertebrates, ranging from birds and mammals to fishes and crabs. However, to fully understand the scope of the impact of PPE litter, more research is needed.

As we only searched articles in English and Dutch and found mainly cases from the UK, USA and The Netherlands, we expect that more examples of interactions between animals and PPE litter can be found from sources in other languages. For example, using reverse image search on a photo encountered on social media, we traced back the source of the report of an entangled bird to a local Italian newspaper (ArezzoNotizie, 2020). This was also done for a photo of an entangled crab, which was encountered on an English website (CGTN, 2021). We were able to trace it back to French social media pages where we also encountered another observation of an entangled crab and the octopus hiding under a face mask (Opération Mer Propre, 2020a, b). To understand the full scale of the problem, we encourage anyone to add their observations to our regularly updated overview, accessible online at www.covidlitter.com. Especially litter pickers, animal rescue centers, bird watchers and nature photographers have proven to play a vital role in observing and sharing interactions of animals with PPE litter, and we encourage them to keep reporting any new observations.

As we deal with a recently introduced and relatively easily recognizable type of litter, monitoring its impact on animals can provide us with a unique insight of the impact such a type of single-use plastic can have. The pandemic is not over yet, and the amount of PPE used may only increase, and will continue to threaten wildlife way beyond the time access to a vaccine becomes available. In addition to this, the already littered items will degrade into micro- and nanoplastics and stay in the environment for hundreds of years (Fadare & Okoffo, 2020; Kassam, 2020). To better understand the scope of the impact of face masks and gloves, it is also important to monitor PPE litter.

To achieve this goal, we acknowledge the importance of citizen science initiatives that collect data on litter, for example during beach cleans (Rambonnet et al., 2019). We encourage citizen science efforts to increase the monitoring of PPE litter and we recommend updating the standardized method for monitoring beach litter, the OSPAR guideline (OSPAR, 2010; Silva et al., 2020). We believe that separate categories for latex gloves and face masks should be added. The Great British Beach

Table 1.

Overview of interactions between animal species and PPE litter with date of observation if known, date of online report, country where it was observed, species name, type of PPE litter, type of interaction and the name of the observer or reporter. An up-to-date version of this table can be found on www.covidlitter.com, where anyone can also add any new or missing observations.

	Date of observation	Date of online report	Country	Species	PPE item	Interaction	Observer or reporter
1	10-04-2020	23-04-2020	Canada	American robin (<i>Turdus migratorius</i>)	Face mask	Entangled	Sandra Denisuk
2	Unknown	14-04-2020	Poland	Sparrow sp. (<i>Passer</i> sp.)	Gloves	Nest material	Marta Szulkin
3	Unknown	11-05-2020	USA	Cat (<i>Felis catus</i>)	Glove	Ingested	ACCT Philly and Art City Vets & Urgent Care
4	03-06-2020	This paper	The Netherlands	Common coot (<i>Fulica atra</i>)	Face mask	Nest material	Marieke Elsinga
5	Unknown	01-07-2020	France	Common octopus (<i>Octopus vulgaris</i>)	Face mask	Other: hiding	Opération Mer Propre
6	19-07-2020	19-07-2020	UK	Gull sp. (<i>Larus</i> sp.)	Face mask	Entangled	RSPCA Essex South
7	19-07-2020	24-07-2020	UK	Peregrine falcon (<i>Falco peregrinus</i>)	Face mask	Entangled	Steve Shiley
8	Unknown	22-07-2020	UK	Red fox (<i>Vulpes vulpes</i>)	Face mask	Entangled	South Essex Wildlife Hospital
9	Unknown	22-07-2020	UK	European hedgehog (<i>Erimaceus europaeus</i>)	Glove	Entangled	South Essex Wildlife Hospital
10	31-07-2020	31-07-2020	USA	Checkered pufferfish (<i>Sphaeroides testudineus</i>)	Face mask	Entangled	Tiffany Menichetti (Clean this beach up)
11	02-08-2020	This paper	The Netherlands	Perch (<i>Perca fluviatilis</i>)	Glove	Entrapped	Brandon Hartley and Marie Diamond (Plastic Spotter)

Table 1.
(Continued.)

	Date of observation	Date of online report	Country	Species	PPE item	Interaction	Observer or reporter
12	24-07-2020	05-08-2020	USA	Dog (<i>Canis lupus familiaris</i>)	Face mask	Ingested	Animal Rescue League of Boston
13	Unknown	07-08-2020	UK	Gull sp. (<i>Larus</i> sp.)	Face mask	Carrying	Roger Lovell
14	11-08-2020	11-08-2020	UK	Gull sp. (<i>Larus</i> sp.)	Face mask	Carrying	Peter Nicholls
15	31-08-2020	01-09-2020	UK	Gull sp. (<i>Larus</i> sp.)	Face Mask	Carrying	Nicholas Hayman
16	Unknown	05-09-2020	UK	Dog (<i>Canis lupus familiaris</i>)	Face mask	Ingestion	University of Glasgow's small animal hospital
17	06-09-2020	This paper	The Netherlands	Common coot (<i>Fulica atra</i>)	Face mask and glove	Nest material	Auke-Florian Hiemstra and Liselotte Rambonnet
18	Unknown	14-09-2020	Italy	Mute swan (<i>Cygnus olor</i>)	Face mask	Other: playing	Paolo Nicolai
19	Unknown	20-09-2020	Italy	Mallard (<i>Anas platyrhynchos</i>)	Face mask	Entangled	Jacopo Casali
20	23-09-2020	23-09-2020	France	Shore crab (<i>Carcinus maenas</i>)	Face mask	Entangled	Opération Mer Propre
21	23-09-2020	23-09-2020	France	Shore crab (<i>Carcinus maenas</i>)	Face mask	Entangled	Opération Mer Propre
22	11-09-2020	15-09-2020	Brazil	Magellanic penguin (<i>Spheniscus magellanicus</i>)	Face mask	Ingested	Argonauta Institute for Coastal and Marine Conservation
23	Unknown	10-10-2020	The Netherlands	Serotine bat (<i>Eptesicus serotinus</i>)	Two face masks	Entangled	Mirjam van Otterlo
24	20-10-2020	23-10-2020	The Netherlands	European hedgehog (<i>Erinaceus europaeus</i>)	Face mask	Entangled	Egelopvang 't Stekeltje
25	30-10-2020	30-10-2020	Malaysia	Long-tailed macaque (<i>Macaca fascicularis</i>)	Face mask	Other: chewing	Mohd Rasfan

Table 1.
(Continued.)

	Date of observation	Date of online report	Country	Species	PPE item	Interaction	Observer or reporter
26	Unknown	24-11-2020	UK	Dog (<i>Canis lupus familiaris</i>)	Face mask	Ingested	Mike Glanton & Zetland Vets Hospital
27	01-01-2021	04-01-2021	The Netherlands	Gull sp. (<i>Larus</i> sp.)	Face mask	Ertangled	Erwin Kompanje
28	01-01-2021	07-01-2021	The Netherlands	Dog (<i>Canis lupus familiaris</i>)	Face mask	Ingested	Janneke van Gerwen

Clean also asked their volunteers to monitor this type of litter in September 2020, which helped to map the extent of PPE litter in the UK (Matthews, 2020). As this material is a potential biohazard precautions should be taken during clean-ups as COVID-19 can survive up to three days on for example plastic surfaces (van Doremalen et al., 2020). Litter monitoring campaigns help us understand the scope of this new category of problematic litter.

Other initiatives call on people to cut up disposable gloves and snip the straps on face masks before discarding them, as this could help prevent animals from getting entangled (RSPCA, 2020; Toliver, 2020). A similar strategy is being used for plastic six-pack rings, which should also be cut up before being discarded to prevent entanglements (Stachowitsch, 2019). In addition, it is recommended to take the impact of PPE litter on the environment into account when developing PPE products (Schweitzer et al., 2018).

The PPE products that are designed to keep us safe are actually harming animals around us. It is striking that all the reported findings of entanglement, entrapment, ingestion, and incorporation of PPE into nests so far involved single-use products. Switching to reusables will result in a 95% reduction in waste, according to the UCL Plastic Waste Innovation Hub (2020). To minimize the amount of COVID-19 litter and its effect on nature, we urge that, when possible, reusable alternatives are used. People may suffer from the coronavirus pandemic, but nature is getting sick of our plastic.

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Author contributions

Auke-Florian Hiemstra: Conceptualization, Investigation, Writing – Original Draft, Photography. Liselotte Rambonnet: Conceptualization, Investigation, Writing – Original Draft. Barbara Gravendeel: Writing Review & Editing, Supervision. Menno Schilthuizen: Writing Review & Editing, Supervision.

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