

LETTERS

Edited by Jennifer Sills

Investigate the origins of COVID-19

On 30 December 2019, the Program for Monitoring Emerging Diseases notified the world about a pneumonia of unknown cause in Wuhan, China (1). Since then, scientists have made remarkable progress in understanding the causative agent, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), its transmission, pathogenesis, and mitigation by vaccines, therapeutics, and non-pharmaceutical interventions. Yet more investigation is still needed to determine the origin of the pandemic. Theories of accidental release from a lab and zoonotic spillover both remain viable. Knowing how COVID-19 emerged is critical for informing global strategies to mitigate the risk of future outbreaks.

In May 2020, the World Health Assembly requested that the World Health Organization (WHO) director-general work closely with partners to determine the origins of SARS-CoV-2 (2). In November, the Terms of Reference for a China-WHO joint study were released (3). The information, data, and samples for the study's first phase were collected and summarized by the Chinese half of the team; the rest of the team built on this analysis. Although there were no findings in clear support of either a natural spillover or a lab accident, the team assessed a zoonotic spillover from an intermediate host as "likely to very likely," and a laboratory incident as "extremely unlikely" [(4), p. 9]. Furthermore, the two theories were not given balanced consideration. Only 4 of the 313 pages of the report and its annexes addressed the possibility of a laboratory accident (4). Notably, WHO Director-General Tedros Ghebreyesus commented that the report's consideration of evidence supporting a laboratory accident was insufficient and offered to provide additional resources to fully evaluate the possibility (5).

As scientists with relevant expertise, we agree with the WHO director-general (5), the United States and 13 other countries (6), and the European Union (7) that greater clarity about the origins of this pandemic is necessary and feasible to achieve. We must take hypotheses about both natural and laboratory spillovers seriously until we have sufficient data. A proper investigation should be transparent, objective, data-driven,

inclusive of broad expertise, subject to independent oversight, and responsibly managed to minimize the impact of conflicts of interest. Public health agencies and research laboratories alike need to open their records to the public. Investigators should document the veracity and provenance of data from which analyses are conducted and conclusions drawn, so that analyses are reproducible by independent experts.

Finally, in this time of unfortunate anti-Asian sentiment in some countries, we note that at the beginning of the pandemic, it was Chinese doctors, scientists, journalists, and citizens who shared with the world crucial information about the spread of the virus—often at great personal cost (8, 9). We should show the same determination in promoting a dispassionate science-based discourse on this difficult but important issue.

Jesse D. Bloom^{1,2}, Yujia Alina Chan³, Ralph S. Baric⁴, Pamela J. Bjorkman⁵, Sarah Cobey⁶, Benjamin E. Deverman³, David N. Fisman⁷, Ravindra Gupta⁸, Akiko Iwasaki^{9,2}, Marc Lipsitch¹⁰, Ruslan Medzhitov^{9,2}, Richard A. Neher¹¹, Rasmus Nielsen¹², Nick Patterson¹³, Tim Stearns¹⁴, Erik van Nimwegen¹⁵, Michael Worobey¹⁵, David A. Relman^{16,17*}

¹Basic Sciences and Computational Biology, Fred Hutchinson Cancer Research Center, Seattle, WA 98109, USA. ²Howard Hughes Medical Institute, Chevy Chase, MD 20815, USA. ³Stanley Center for Psychiatric Research, Broad Institute of Massachusetts Institute of Technology and Harvard University, Cambridge, MA 02142, USA. ⁴Department of Epidemiology and Department of Microbiology & Immunology, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA. ⁵Division of Biology and Biological Engineering, California Institute of Technology, Pasadena, CA 91125, USA. ⁶Department of Ecology and Evolution, University of Chicago, Chicago, IL 60637, USA. ⁷Dalla Lana School of Public Health, University of Toronto, Toronto, ON M5S 1A8, Canada. ⁸Cambridge Institute of Therapeutic Immunology & Infectious Disease, Cambridge, UK. ⁹Department of Immunobiology, Yale University School of Medicine, New Haven, CT 06519, USA. ¹⁰Department of Immunology and Infectious Diseases and Center for Communicable Disease Dynamics, Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, MA 02115, USA. ¹¹Biozentrum, University of Basel and Swiss Institute of Bioinformatics, Basel, Switzerland. ¹²Department of Integrative Biology and Department of Statistics, University of California, Berkeley, CA 94720, USA. ¹³Department of Human Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA. ¹⁴Department of Biology and Department of Genetics, Stanford University, Stanford, CA 94305, USA. ¹⁵Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721, USA. ¹⁶Department of Medicine and Department of Microbiology & Immunology, Stanford University School of Medicine, Stanford, CA 94305, USA. ¹⁷Center for International Security and Cooperation, Stanford University, Stanford, CA 94305, USA. *Corresponding author. Email: relman@stanford.edu

REFERENCES AND NOTES

1. "Undiagnosed pneumonia—China (Hubei): Request for information," ProMED post (2019); <https://promedmail.org/promed-post/?id=6864153>.
2. World Health Assembly Resolution 73.1: COVID-19 response (2020); https://apps.who.int/gb/ebwha/pdf_files/WHA73/A73_R1-en.pdf.
3. WHO, "WHO-convened global study of the origins of SARS-CoV-2" (2020); www.who.int/publications/m/item/who-convened-global-study-of-the-origins-of-sars-cov-2.



4. WHO, "WHO-convened global study of origins of SARS-CoV-2: China part" (2021); www.who.int/publications/item/who-convened-global-study-of-origins-of-sars-cov-2-china-part.
5. WHO, "WHO director-general's remarks at the Member State Briefing on the report of the international team studying the origins of SARS-CoV-2" (2021); www.who.int/director-general/speeches/detail/who-director-general-s-remarks-at-the-member-state-briefing-on-the-report-of-the-international-team-studying-the-origins-of-sars-cov-2.
6. US Department of State, "Joint statement on the WHO-Convened COVID-19 origins study" (2021); www.state.gov/joint-statement-on-the-who-convened-covid-19-origins-study/.
7. Delegation of the European Union to the UN and other International Organizations in Geneva "EU statement on the WHO-led COVID-19 origins study" (2021); <https://eeas.europa.eu/delegations/un-geneva/95960/eu-statement-who-led-covid-19-origins-study-en>.
8. J. Hollingsworth, Y. Xiong, "The truth-tellers: China created a story of the pandemic. These people revealed details Beijing left out," *CNN* (2021).
9. A. Green, L. Wenliang, *Lancet* **395**, 682 (2020).

10.1126/science.abj0016

Ban veterinary use of diclofenac in Europe

In Europe, vulture recovery has been an important conservation success story (1). This success may now be jeopardized by the use of diclofenac in Europe's pastoral landscapes. Although diclofenac had already caused a rapid and catastrophic 95% decline in Asian vulture populations (2), the non-steroidal anti-inflammatory drug was approved for veterinary use in Spain in 2013 (3). Although measures for the safe disposal of carcasses of livestock treated with diclofenac are supposed to prevent avian scavengers from feeding on contaminated carrion (4), a Spanish cinereous vulture (*Aegypius monachus*) was found dead,

Downloaded from <http://science.sciencemag.org/> on May 15, 2021

PHOTO: MARIO SUAREZ FORRAS/MINDEN PICTURES



A Spanish cinereous vulture (*Aegypius monachus*) was found poisoned by diclofenac in September 2020.

poisoned with diclofenac (5), in September 2020. European regulatory authorities should permanently ban diclofenac use in livestock before the tragedy met by Asian vultures repeats itself in Europe.

Vulture breeding populations in Spain represent more than 90% of the total European vulture population (6). Diclofenac use in livestock could contribute an additional annual mortality rate of 0.9% to 7.7% in Spanish griffon vultures (7). The vulture discovered in September was tracked by GPS tag. Given that untagged birds are harder to find, it is likely that more vultures have been poisoned by diclofenac but have not been found. The genus of the recently discovered bird is also ominous; previous diclofenac deaths have only affected species of the genus *Gyps* (2, 8).

If bold measures are not immediately taken throughout Europe, the consequences for European vultures could be severe. In addition to posing an indirect threat, the legal availability of diclofenac may provide a highly efficient weapon to lawbreakers who wish vultures harm. European and national decision-makers should embrace a precautionary approach that promotes treating livestock with cost-effective, vulture-safe alternatives to diclofenac, such as meloxicam (9). These decisions would protect European avian scavengers and align with the new European Green Deal action plan for restoring biodiversity (10).

Antoni Margalida^{1*}, Rhys E. Green², Fernando Hiraldo³, Guillermo Blanco⁴, José A. Sánchez-Zapata⁵, Andrea Santangeli⁶, Olivier Duriez⁷, José A. Donazar³

¹Instituto de Investigación en Recursos Cinegéticos, Consejo Superior de Investigaciones Científicas (CSIC), Universidad de Castilla-La Mancha, E-13005 Ciudad Real, Spain.

²Department of Zoology, University of Cambridge, Cambridge CB2 3EJ, UK. ³Estación Biológica de Doñana, CSIC, E-41092 Sevilla, Spain. ⁴Museo Nacional de Ciencias Naturales, CSIC, E-28006 Madrid, Spain. ⁵Universidad Miguel Hernández, E-03202 Elche, Spain. ⁶Research Centre for Ecological Change, Organismal and Evolutionary Biology Research Programme, University of Helsinki, 00014 Helsinki, Finland. ⁷Centre d'Ecologie Fonctionnelle et Evolutive, University of Montpellier, Centre National de la Recherche Scientifique, École Pratique des Hautes Études, Institut de Recherche pour le Développement, University of Paul Valéry Montpellier 3, Montpellier, France.

*Corresponding author. Email: a.margalida@csic.es

REFERENCES AND NOTES

1. R. Safford et al., *Bird Conserv. Int.* **29**, 1 (2019).
2. J. L. Oakset et al., *Nature* **427**, 630 (2004).
3. A. Margalida et al., *Science* **346**, 1296 (2014).
4. M. J. I. Chaudhry et al., *Bird Conserv. Int.* **22**, 389 (2012).
5. M. Herrero-Villar et al., *Sci. Tot. Environ.* **782**, 146890 (2021).
6. A. Margalida et al., *J. Appl. Ecol.* **47**, 931 (2010).
7. R. E. Green et al., *J. Appl. Ecol.* **53**, 993 (2016).
8. R. E. Green et al., *J. Appl. Ecol.* **41**, 793 (2004).
9. D. Swarup et al., *Anim. Conserv.* **10**, 192 (2007).
10. European Commission, A European Green Deal (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en).

10.1126/science.abj0131

Salmon aquaculture threatens Patagonia

In March, a massive die-off of farmed salmon sent more than 2.2 million kilos of rotting fish biomass into the fjords and channels of the Pacific Patagonian

wilderness (1), critical areas for biodiversity conservation. The mass mortality event is part of a pattern in which industrial salmon farming increases eutrophication and boosts harmful micro-algae blooms (2), which enter gills and suffocate fish (3). In turn, decomposition of salmon carcasses leads to increased dissolved organic matter, which, in combination with human-induced ocean warming, facilitates the occurrence of more algal blooms (4). With a new constitutional act under discussion, Chile should seize this opportunity to add regulations that will stop the cycle and protect the valuable Patagonian region.

Pacific Patagonia remained mostly pristine until the 1980s (5). The region served as one of the last territories of thriving blue whales (5) and provided non-breeding habitat for long-distance migratory shorebirds breeding as far away as Alaska (6). Salmon aquaculture markedly changed this vast coastal landscape from Chiloé Archipelago to Tierra del Fuego, affecting even remote channels without any previous signs of human activity other than from Indigenous cultures (7). Despite repeated warnings regarding socio-environmental impacts (8), salmon aquaculture surpassed 1,000,000 tons in 2020 and is now one of the largest economic activities in Chile, the second-largest salmon producer in the world (9). In addition to pollution generated by the industry, the regular escape of farmed salmon from broken cages adds non-native mesopredators to food-webs and affects wildlife by transferring aquaculture-associated diseases (10) and antibiotic resistant bacteria and genes, which can take hold in wild animals (11).

The international community, which serves as the market for Chile's salmon, can leverage its economic power to convince Chile to take action to protect this unique biodiversity hotspot from the environmental effects of salmon aquaculture. Existing government regulations and industry standards must be strengthened. For example, current sustainable aquaculture labelling schemes label some salmon operations as "sustainable" without fully evaluating impacts to wildlife and the surrounding environment (6, 11). The United Nations should push the Chilean government to halt the current expansion of salmon industry toward southern latitudes, especially in the Magallanes region, one of the last bastions of the Patagonian wilderness. Furthermore, a comprehensive monitoring program should be put in place to conduct annual reviews, give

Where Science Gets Social.

AAAS.ORG/COMMUNITY



AAAS' Member Community is a one-stop destination for scientists and STEM enthusiasts alike. It's "Where Science Gets Social": a community where facts matter, ideas are big and there's always a reason to come hang out, share, discuss and explore.

Member
COMMUNITY
AAAS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

warnings to the industry where necessary, and dismantle aquaculture operations that violate the regulations.

The United Nations should take advantage of the socio-political momentum in Chile. In October 2020, 79% of voters approved the creation of a new constitutional act for Chile, with the potential to address a variety of issues, including a wide range of environmental regulations (12). The proposed legislation presents an opportunity to place much-needed limits on aquaculture development. The act will take shape with the input of independent candidates rather than the current parliamentarians and senators who have contributed to the precarious aquaculture cycle. After three decades of salmon industry development, this process could finally lead to policies that protect the Pacific Patagonian wilderness.

Juan G. Navedo^{1,2,3*} and Luis Vargas-Chacoff^{3,4,5}

¹Estación Experimental Quempillén (Chiloé), Facultad de Ciencias, Universidad Austral de Chile, Chile. ²Bird Ecology Lab, Instituto de Ciencias Marinas y Limnológicas, Universidad Austral de Chile, Chile. ³Instituto de Ciencias Marinas y Limnológicas, Facultad de Ciencias, Universidad Austral de Chile, Casilla 567, Valdivia, Chile. ⁴Centro FONDAP de Investigaciones en Dinámica de Ecosistemas Marinos de Altas Latitudes, Universidad Austral de Chile, Casilla 567, Valdivia, Chile. ⁵Integrative Biology Group, Universidad Austral de Chile, Valdivia, Chile.

*Corresponding author. Email: jgnavedo@uach.cl

REFERENCES AND NOTES

1. Ecoceános, "Millions of salmon die in a new sanitary-environmental disaster in the fjords and channels of Chiloe and Aysen" (2021); www.ecoceanos.cl/2021/04/millions-of-salmon-die-in-a-new-sanitary-environmental-disaster-in-the-fjords-and-channels-of-chiloe-and-aysen/.
2. C. Folke, N. Kautsky, M. Troell, *J. Environ. Manage.* **40**, 173 (1994).
3. J. León-Muñoz *et al.*, *Sci. Rep.* **8**, 1330 (2018).
4. H. W. Paerl, J. Huisman, *Science* **320**, 57 (2008).
5. R. Hucke-Gaete, P. Lo Moro, J. Ruiz, Eds., "Conservando el mar de Chiloé, Palena y Guaitecas" (Universidad Austral de Chile, 2010) [in Spanish].
6. J. G. Navedo, V. Araya, C. Verdugo, *Sci. Tot. Environ.* **777**, 146004 (2021).
7. P. A. Marquet *et al.*, *Science* **370**, 669 (2021).
8. J. R. Barton, A. Floydsand, *Glob. Environ. Chang.* **20**, 739 (2010).
9. Servicio Nacional de Pesca, "Informe sobre uso de antimicrobianos en la salmicultura nacional: Año 2020" (Gobierno de Chile, 2021) [in Spanish].
10. C. Vargas-Lagos *et al.*, *Fish Shellfish Immunol.* **90**, 1 (2020).
11. F. C. Cabello, H. P. Godfrey, A. H. Buschmann, H. J. Dölz, *Lancet Infect. Dis.* **126**, 127 (2016).
12. Gob.cl, Proceso Constituyente (www.gob.cl/procesoconstituyente/) [in Spanish].

10.1126/science.abj1044

ERRATA

Erratum for the Report "Manta-like planktivorous sharks in Late Cretaceous oceans" by R. Vullo *et al.*, *Science* **372**, eabi9203 (2021). Published online 16 April 2021; 10.1126/science.abi9203

Investigate the origins of COVID-19

Jesse D. Bloom, Yujia Alina Chan, Ralph S. Baric, Pamela J. Bjorkman, Sarah Cobey, Benjamin E. Deverman, David N. Fisman, Ravindra Gupta, Akiko Iwasaki, Marc Lipsitch, Ruslan Medzhitov, Richard A. Neher, Rasmus Nielsen, Nick Patterson, Tim Stearns, Erik van Nimwegen, Michael Worobey and David A. Relman

Science **372** (6543), 694.
DOI: 10.1126/science.abj0016

ARTICLE TOOLS <http://science.sciencemag.org/content/372/6543/694.1>

REFERENCES This article cites 1 articles, 0 of which you can access for free
<http://science.sciencemag.org/content/372/6543/694.1#BIBL>

PERMISSIONS <http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.

Copyright © 2021 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works