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NOTES AND COMMENTS

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COLOSS survey: global impact of COVID-19 on bee research

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The socio-economic impacts of COVID-19 on society have yet to be truly revealed; there is no doubt that the pandemic has severely affected the daily lives of most of humanity. It is to be expected that the research activities of scientists could be impacted to varying degrees, but no data exist on how COVID-19 has affected research specifically. Here, we show that the still ongoing COVID-19 pandemic has already diversely and negatively affected bee research at a global level. An online survey disseminated through the global COLOSS honey bee research association showed that every participant ($n = 230$ from 56 countries) reported an impact on one or more of their activities. Activities that require travelling or the physical presence of people (meetings and conferences, teaching and extension) were affected the most, but also laboratory and field activities, daily operations, supervision and other activities were affected to varying degrees. Since the basic activities are very similar for many research fields, it appears as if our findings for bee research can be extrapolated to other fields. In the light of our data, we recommend that stakeholders such as governments and funding bodies who support research should facilitate the wide implementation of web-based information technology required for efficient online communication for research and education, as well as adequately loosened restriction measures with respect to field and laboratory work. Finally, increased flexibility in administration and extension of research grants and fellowships seem to be needed. It is apparent that adequate responses by all stakeholders are required to limit the impact of COVID-19 and future pandemics on bee science and other research fields.

Keywords: COLOSS; *Apis mellifera*; coronavirus; COVID-19; honey bee; pandemic; research; extension

After the first cases of COVID-19 were reported in Wuhan, China in December 2019, the World Health Organization declared the COVID-19 outbreak as a global health emergency on 30 January 2020 and later many affected countries imposed nationwide lockdowns. By 26 March, 1.7 billion people worldwide were under some form of lockdown, which increased to 3.9 billion people by the first week of April, representing more than half of the world's population (https://coronavirus.jhu.edu/; access date 10 June 2020). It is therefore obvious that the impacts of COVID-19 on humanity have been far-reaching (McKibbin and Roshen, 2020). Since the pandemic is devastating communities across the globe, there is an apparent need for global data across communities to quell it, and to prepare for the next one (Lang 2020), but its effects on research have not been thoroughly assessed. Here, we investigate the impact of the restrictions implemented to control the pandemic on research focussed on bees at a global scale. As in most other research fields, bee science is founded on several main pillars, which could all be affected by the pandemic to varying degrees: meetings and conferences to exchange ideas and results; field work and laboratory work to generate data; desk work to analyse and summarize the data for publication; applications for funds and grants, and dissemination of knowledge and results via teaching and extension activities. Since these research pillars require different activities,

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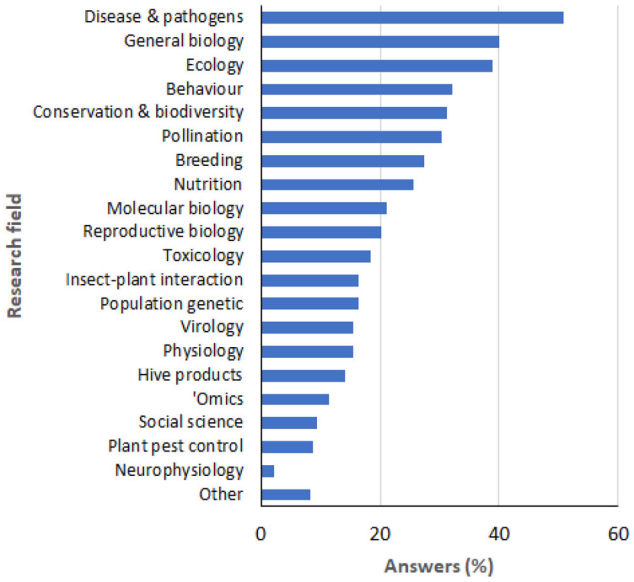

Figure 1. Bee research fields in which the survey participants are involved (multiple answers were possible; Other = fields grouped with less than 2%, e.g. economics, management, taxonomy, microbiome, invasive species) ($n = 227$).

related services and social interactions, we expect those which require physical presence of contact people to be affected most by social distancing measures meant to reduce spread of the novel severe acute respiratory syndrome coronavirus 2.

The COLOSS (prevention of honey bee COlony LOSSes; www.coloss.org; Williams et al., 2012) association, with more than 1,400 members from 101 countries, has the power to rapidly coordinate urgent responses to pressing issues in bee research. To estimate the impact of COVID-19 restrictions on bee research for the first time, the Executive Committee of COLOSS developed an internet-based survey that was disseminated to all members and relevant stakeholders to obtain data on which bee research activities had been affected. To participate in the survey, COLOSS membership was not required, and although the association is focussed on honey bees, the survey was also disseminated more widely within the bee research community.

Our survey was sent out on 1 May 2020 to all COLOSS members through an electronic newsletter that requested both individual participation and further onward dissemination of the questionnaire. A reminder to complete the survey was sent on 12 May 2020. The survey closed on 17 May 2020. The survey was composed of thirty-six questions (Table S1, Supplementary material). They covered personal information about the participants' role and their assessment of the impact of COVID-19 on their ability to conduct research and instruction related to bees. The survey also asked questions regarding ongoing mitigation measures, as well as economic and hedonic traits. Answer fields to questions were either open ended or gave options (pick-one-answer or multiple-choice). Most questions on the impact of current restriction measures gave four options: not impacting, slightly impacting, impacting, or severely impacting. Given the timing of the survey in the early stages of the pandemic, some questions about economic and other consequences required open-answers. None of the answers were mandatory. To compare the impact on different groups, we converted the answers of questions 7–26 into numerical values (not impacting =0, slightly = 1, impacting = 2 and severely = 3).

In total, 230 researchers from 56 countries responded (Table S2, Supplementary material). It must be noted that the participating countries were at different stages of the pandemic and countermeasures. Individuals from the USA contributed the most participants (23.5%), followed by the UK and Spain. The survey was mostly completed by employees from academia (58.6%), followed by government (19.8%) and then private companies in the bee research sector (12.3%). Within these categories, 47.3% of the surveys were completed by researchers, 16.4% by teachers or lecturers, 8.8% by students, and 8.4% by people occupying administrative positions within their organization (leaders/managers or deans/directors). Most of investigators who contributed worked with the western honey bee, *Apis mellifera* (85.4%), but 15 other species were also listed, including other honey bee (*Apis*) species, bumble bees (*Bombus* spp.), solitary bees, and also bee parasites and predators. The most common research topics among contributors were bee diseases and pathogens (50.7%), biology (40.1%), ecology (38.3%), behaviour (32.2%), conservation and biodiversity (31.3%), and pollination (30.4%) (Figure 1). An individual respondent could have performed research on several topics.

The survey results on the impact of COVID-19 are shown in Figure 2. It was striking that we did not record any response with a score of zero, indicating that everyone has been affected in some way. Most participants (92.0%) rated meetings and conferences as being impacted, with 45.3% rating it in the category 'severe impact'. This was followed by highest 'severe impact' ratings on lab work (44.3%), field work (38.6%), sample collection (35.9%), training/teaching (32.8%), daily operations (28.9%) and sample shipment (28.0%). On the other hand, desk work (4.4%) and sample storage (6.5%) returned the lowest 'severe impact' ratings (with 59.7% of respondents asserting that sample storage was 'not affected'). The lower the level of education, the more the student supervision was affected: bachelor student education was affected (75.1% of respondents slightly to severely impacted) more than education of master students (73.5%) and PhD students (70.6%). This is in line with the general higher supervision needs of students early in their careers.

The results also raised concerns about the administration of current research funding. Indeed, the majority

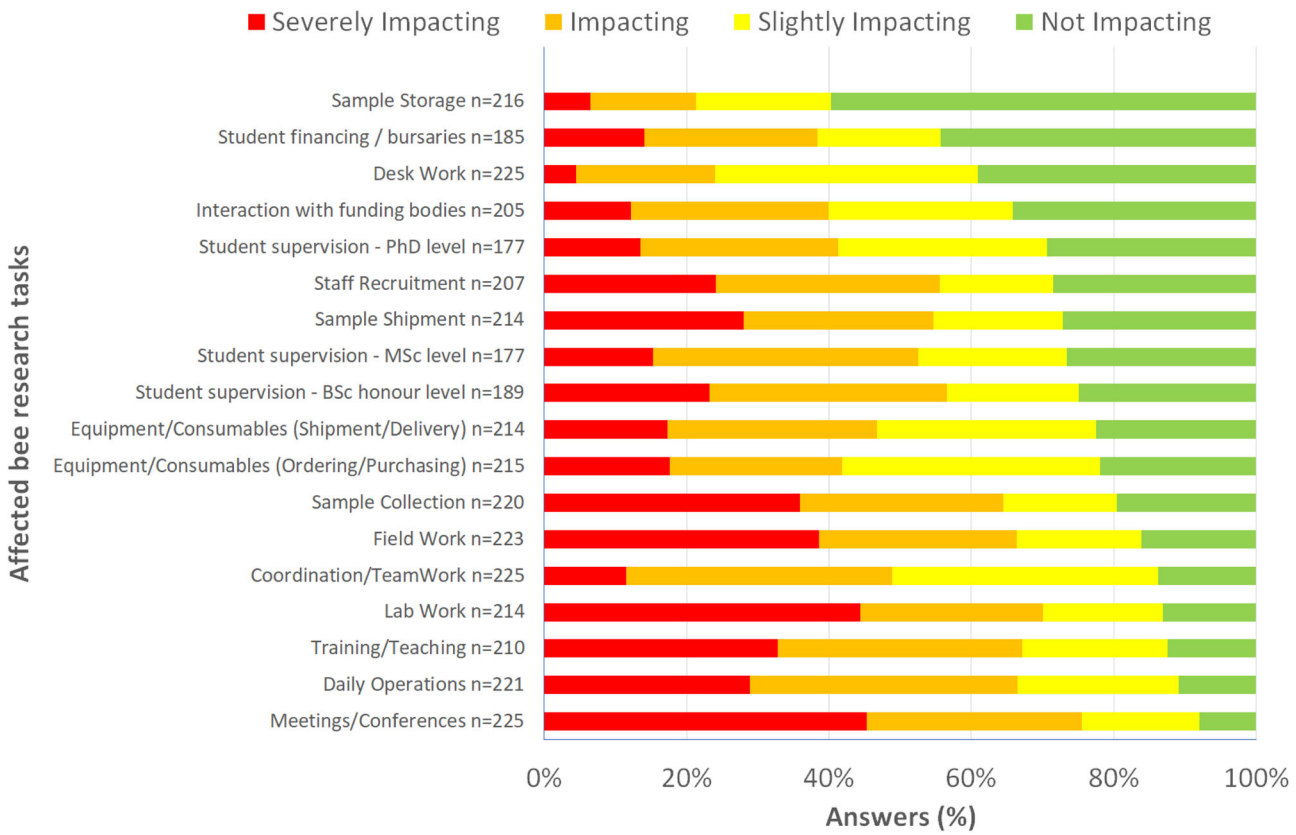

Figure 2. Impact of COVID-19 on different pillars of bee research, ranked according to the sum of the three categories stating an impact (n = number of answers per pillar).

of participants believed that interactions with funding bodies (i.e. negative impact on grants) will be impacted. Only 13.5% of participants were reassured by funding bodies that their grants will be extended. More than half of the participants (53.5%) received negative or no answer at all from funding bodies concerning possible funding extensions, while 55.7% felt that there would be negative impacts on student grants. As 39.1% of participants reported that desk work was not affected, factors raised included technical issues such as a lack of adequate IT facilities at home, and suboptimal working environments, such as simultaneous childcare duties. Eight participants did, however, report increased scientific productivity, thanks to the ability to submit long overdue manuscripts, which was possible thanks to the increased desk work hours. Nevertheless, several participants reported the risk of a diminished research output for the next year due to lack of data collection during the current season.

Our survey clearly demonstrates that within 2.5 months after COVID-19 was declared a pandemic by WHO, it had resulted in immediate and wide-ranging disruptions to bee research, which are probably similar for other research fields in natural sciences. With the pandemic continuing its course, our data can obviously only display the impact at the time of surveying. Follow-up studies should therefore be conducted.

The results suggest that disease and pathogens are at present the most prevalent topic amongst the participating bee researchers and that our survey participants work in a wide range of topics (Figure 1).

Activities that require travelling or physical presence of people (meetings and conferences, teaching, extension and team work in the field or laboratory) were affected the most (Figure 2). Even though personal contacts will also be important in the future, a lesson learnt from this pandemic appears to be that many aspects can be satisfactorily continued via online tools. Therefore, in order to reduce carbon footprint globally and to guard research against future pandemics, an even stronger focus on IT solutions appears desirable. Desk work efficiency was almost secured thanks to the implementation of home-office solutions, but while in the short term this might even result in increased scientific productivity thanks to the submission of long-standing manuscripts, it is to be expected that a lack of new data collection will reduce productivity in the near future.

We found that restrictions mostly affected laboratory work and field experiments, which are essential to generate data and are often season dependent in bee research. Restrictions also delayed the acquisition of samples, the shipping of reagents or samples from one place to another, or even movement of living

study organisms required for completion of research projects (such as study on reproductive biology and breeding programs, for instance). Other studies, such as the collection of data on honey bee colony losses from beekeepers, could still be accomplished despite the restrictions, as in the majority of countries this is now conducted online (Gray et al., 2019). However, given that farming (including beekeeping) is considered an essential activity, and thus was allowed in most countries even during lockdown and social distancing measures (e.g. Defra, 2020), we suggest that policy makers should also consider farming-related research as essential, thus developing special regulations for field and laboratory staff to allow continuation of their work while ensuring health safety (see Rutz et al., 2020).

With respect to economic indicators, we received few answers, which reported a wide range of scenarios relating to extra labour requirements and costs. Some participants ($N = 15$) concluded that the time lost, and the proactive attitude of their research groups, will never be completely recovered. This might indicate that a quantitative evaluation of the economic impact (also including details of different contributory factors), together with a comprehensive social impact assessment, will be required over the long-term. In addition, as restrictions in many countries are still being enforced, and travelling between countries is extremely limited, the current picture provided by our survey will need to be updated as government policies change. Our current results nevertheless highlight the need for specific mitigation measures to reduce the impact of this and future pandemics on research.

In the light of our present data, we can recommend that stakeholders, such as governments and funding bodies, should not only facilitate widespread implementation of web-based IT solutions required for efficient online communication, but should also adopt flexibility in administration, especially of research grants and fellowships, including the possibility of no-cost extensions or longer term funding to limit the impact of COVID-19 or any future pandemics on vital research and education. Since the basic activities are very similar for many research fields, it appears as if our findings can be extrapolated to other fields.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Supplementary material

Supplementary Tables are available via the 'Supplementary' tab on the article's online page (http://dx.doi.org/10.1080/00218839.2020.1799646).

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