

TRANSLATION



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Investigation Report

Adopted by the Board for Investigation of Misconduct in Research
24 November 2017

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1. Respondents

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Uppsala University

Peter Eklöv

Professor
Department of Ecology and Genetics, Limnology
Uppsala University

2. Complainants

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Ph.D., Department of Biology, Norwegian University of Science and Technology

Josefin Sundin

Ph.D., Department of Neuroscience, Uppsala University

Dominique Roche

Ph.D., Institute of Biology, Université de Neuchâtel

Graham Raby

Ph.D., Great Lakes Institute for Environmental Research, University of Windsor

Ben Speers-Roesch

Ph.D., Department of Biology, University of New Brunswick

Sandra Binning

Ph.D., Institute of Biology, Université de Neuchâtel

Timothy Clark

Ph.D., Institute for Marine and Antarctic Studies, University of Tasmania

3. Description of the case

On 20 June 2016, Uppsala University received a complaint of misconduct in research against Oona Lönnstedt and Peter Eklöv. The suspicions concerned the article “Environmentally relevant concentrations of microplastic particles influence larval fish ecology”, published in June 2016 in the journal *Science*.

Lönnstedt and Eklöv both hold positions at the Department of Ecology and Genetics at Uppsala University.

As the complainants requested in their communication that the Expert Group for Misconduct in Research at the Central Ethical Review Board (‘the Expert Group’)

should give an opinion on the complaint, on 27 June 2016 Vice-Rector Johan Tysk requested an opinion from the Expert Group.

In accordance with the guidelines in force at the time – the Regulations about the procedure in case of a person being accused of scientific misconduct (UFV 2010/664) – Vice-Rector Johan Tysk also decided, on 5 July 2016, to initiate a preliminary investigation. The preliminary investigation was conducted by Professor Birgitta Bergman, Stockholm University, Professor Per Jensen, Linköping University, and Legal Officer Magnus Hallberg, Uppsala University. The preliminary investigation delivered its final report on 31 August 2016 (*appendix 1*). The report concluded that the investigators had not found evidence that misconduct in research had occurred.

The Expert Group delivered its opinion to Uppsala University on 21 April 2017. The Expert Group found that the researchers against whom the complaint was made were guilty of research misconduct. On 11 May 2017, having considered the opinion, the Vice-Rector decided to turn the matter over to the Vice-Chancellor for a decision.

In accordance with the current Guidelines on the procedure for handling alleged misconduct in research (UFV 2016/1079), the Vice-Chancellor decided on 29 May 2017 to forward the complaint and the Expert Group's opinion to the Board for Investigation of Misconduct in Research at Uppsala University ('the Board') for further investigation before a decision by the Vice-Chancellor.

Lönnstedt and Eklöv were informed on 29 May 2017 of the Vice-Chancellor's decision to forward the complaint to the Board. The Board has held separate meetings with Eklöv (27 July 2017) and Lönnstedt (18 September 2017). They were later given the opportunity to respond to individual questions and to state their view of additional material that has come to light in the case.

On 24 July 2017 the Board entrusted an expert with the task of investigating whether misconduct in research had occurred. The expert engaged for this purpose was Professor Erik Petersson, Swedish University of Agricultural Sciences. Petersson delivered his opinion on 8 September 2017, with supplementary comments on 23 October 2017.

The Board has considered the matter at four of its meetings, on 21 June, 19 September, 18 October and 24 November 2017.

One of the Board's members, Legal Officer Magnus Hallberg, has not participated in the consideration of this matter by the Board. Hallberg participated in the preliminary investigation in 2016 and was held to be disqualified.

4. Starting points for the Board's assessment

In assessing the suspicions of misconduct, the Board has started out from the complaint and the Expert Group's opinion.

The guidelines in force at Uppsala University at the time of the contested research were not the same as those now in force. In dealing with the matter, the Board has applied the procedural rules now in force. The situation regarding the substantive rules, i.e. the rules defining what is deemed misconduct in research, and the former provision concerning intention, is different. This is because the new rules are more stringent, in the sense that

liability can now be found in the case of gross negligence on the part of the researcher, whereas the older guidelines required intention. Fundamental due process interests (the principle of legality) dictate that liability cannot be imposed retroactively.

Accordingly, in this respect the Board must apply the older guidelines (UFV 2010/664). These state the following that is relevant for the present purposes:

‘Scientific misconduct’ means:

1. Falsification and fabrication
2. Plagiarism
3. Unauthorised use of information given in confidence
4. Unwarranted assertion of authorship
5. Failure to follow established recommendations on obtaining approval from relevant agencies (e.g. ethical committees on human research and animal experiments, isotope committees, the Swedish Data Protection Authority, the Medical Products Agency, etc.).

For liability to be found, the misconduct must have been committed intentionally.

5. Brief description of the research

The research project concerned involves a study of how fish larvae and fish fry are affected by microplastic particles. The results of the study were published in the journal *Science* (see below). This article reported that microplastic particles in an aquatic environment had a clear effect on fish fry. For example, those that had been exposed to microplastic particles were less active than those that had not been exposed and they did not seek to avoid predators in the same way as those that had not been exposed to microplastic influence.

6. The complaint

The complaint concerns suspected misconduct in the research underlying the research article “Environmentally relevant concentrations of microplastic particles influence larval fish ecology”, which was published in the journal *Science* in 2016. The suspected misconduct concerns four areas:

1. lack of raw data,
2. problems in the published account of the conduct of the experiments on which the article is based,
3. the statistical processing and analysis of data obtained from the experiments, and
4. discrepancies between the experiments as reported and eye witness accounts.

7. Opinion of the Expert Group

The Expert Group has principally considered the issues of ethical approval for animal experimentation, the preservation of original data and the conduct of the experiments and has concluded that misconduct in research has occurred with respect to ethical approval for animal experimentation and the preservation of original data.

7.1 Ethical approval for animal experimentation

The research article in *Science* states that the ethical committee on animal experiments had approved the experiments concerned. The Expert Group is of the opinion that the claim regarding approval is not true. Eklöv and Lönnstedt have repeated this claim in their contacts with the Expert Group. Ethical approval for animal experimentation was issued in the case, but for fish species other than those in the experiments concerned and for species from another body of water. Moreover, this approval was issued after the experiments reported in the research article reportedly started. The Group finds that, by deliberately stating that ethical approval for animal experimentation had been issued, Eklöv and Lönnstedt have committed research misconduct.

7.2 Preservation of raw data

The Expert Group notes that Eklöv and Lönnstedt have stated that the lack of original data was due to the theft of a computer but that most of the original data were stored in the University's database. The article also states that the data are archived in the database. The authors also assert that the original data are available in the supplementary material accompanying the article. The Expert Group states that the requirement that original data for research be saved and kept available is absolute. Some type of back-up is therefore essential in case, for example, a computer disappears. The Expert Group's interpretation is that the fact that Eklöv and Lönnstedt have produced no more than vague fragments of original data and no traceable data files in the original in support of the research presented in the article leads to a suspicion that the research was not carried out, at any rate not to the extent stated. The Expert Group also questions whether the research continued for the entire period stated in the case. In the opinion of the Expert Group, the defects regarding original data are so serious from a research ethics perspective that Eklöv and Lönnstedt's inability to present original data for the research means they have committed research misconduct.

7.3 Conduct of the experiments

The Expert Group also questions Eklöv and Lönnstedt's statements regarding the findings reported in the article and the conduct of the experiments. The Expert Group has therefore attempted to substantiate both the findings and the research where these have been called into question. Thus, for example, the article states that there were four airstones per aquarium. The Expert Group has requested pictorial documentation but the respondents have not produced this. Further, the article reports significant hatching rate/mortality in the eggs/fish fry groups that had been exposed to microplastic particles.

The Expert Group also noted that the experiments were conducted without separating out the detergent that is present in the concentrated particle suspension. If the experiments were conducted in the manner stated by the authors, the Expert Group considers that the interpretation of the entire series of experiments and the work as a whole must be called into question due to the lack of adequate control experiments.

The article in *Science* contains further statements that have been questioned by the complainants. Although Eklöv and Lönnstedt have been given several opportunities to explain these circumstances, the Expert Group considers that questions remain. The absence of original data and the fact that it is essentially a case of one party's word against the other's lead the Expert Group to conclude that it cannot adopt a position on these matters.

7.4 Other comments

In view of all that has been observed, the Expert Group considers it remarkable that Uppsala University found no evidence, in its preliminary investigation, that research misconduct had occurred in the research conducted by Eklöv and Lönnstedt.

The Expert Group's overall conclusion is that Eklöv and Lönnstedt are guilty of research misconduct. Although Lönnstedt was the person who, in practice, was responsible for most of the alleged research, this does not exempt Eklöv of responsibility. In his role as senior researcher, Eklöv had considerable responsibility for what occurred. Eklöv and Lönnstedt therefore share responsibility for the deficiencies cited.

8. Opinion of the expert engaged by the Board

The Board appointed Professor Erik Petersson of the Swedish University of Agricultural Sciences as expert in this case. In his investigation, Petersson divided the matter into five parts: the status of the experiment in terms of animal experiment ethics; the original complaint; the 20 questions that the complainants raised about the study (mentioned earlier), supplemented by 11 different points; a further 10 questions/accusations from the complainants; and Lönnstedt and Eklöv's response to questions/accusations.

With regard to the status of the experiment in terms of animal experiment ethics, the expert considers it clearly established that Lönnstedt and Eklöv did not have an approved ethical application for animal experimentation when the experiment was conducted, as they claim in the article. It is therefore highly probable that Lönnstedt and Eklöv have committed offences against the Animal Welfare Act. When they had an application approved by the Uppsala Ethical Committee on Animal Experiments, on 26 June 2015 (reg. no C59/15), the expert states that it differed in several respects from what is stated in the article in *Science*: the animal collection sites, the facility where the experiments were conducted and the design of the experiments. The expert considers that the assertion that such approval existed is untrue and therefore constitutes misconduct.

With regard to the other accusations, the expert considers it difficult to prove that misconduct in research really occurred. The expert states that Lönnstedt and Eklöv have not documented a timeline of their own showing what was done when, which has made it difficult for them to respond to some of the complainants' accusations.

In addition, the expert sees several problematic obscurities in the account of the design of the experiment. With regard to the change of water without losing microplastic particles, the expert considers that it could very well have been done as described by Lönnstedt and Eklöv. However, no one saw Lönnstedt examine the bottom sediment to see whether microplastic particles were present there. Moreover, no one had been asked to carry out the water change as described when Lönnstedt was away from Ar Research Station on 9–10 May 2015.

In addition, the expert states that it is strange that Lönnstedt (and Eklöv) made the effort of working with three types of *Artemia* (small crustaceans) to obtain suitable *nauplii* (larvae used as food) without reporting this in the Supplementary Materials. This is interpreted as carelessness almost verging on gross negligence, since this point is important for the entire design of the experiment. However, the expert considers it difficult to prove intention.

The expert also finds it very difficult to reconcile the care/custody of the perch eggs with the timeline provided, and considers that the information provided in the article in *Science* is misleading. He states that it is strange that Lönnstedt (and Eklöv) did not keep convincing records of this and considers there is a suspicion that certain timings have been reconstructed after the event. The expert notes that Lönnstedt and Eklöv write in the *Science* article that four airstones were used, but the available pictures only show one. The expert also finds it difficult to reconcile all the statements provided about the number of perch eggs used in the study. Lönnstedt and Eklöv could easily have refuted the criticism if they had documented everything much better.

The expert finds it strange that the effort was made to measure the temperature and salinity every day without then using these values, stating instead that they followed the natural values. These measurements were not included in the instructions that others at the research station received for management of the experiment during Lönnstedt's absence on 9–10 May 2015.

According to Lönnstedt and Eklöv, information and data are missing because the only copy containing the full set of information about the study was on a single computer and this computer was stolen (along with one or more separate hard disks). Lönnstedt and Eklöv assumed that the information in Lönnstedt's computer had been automatically backed up to Uppsala University's servers, but for some reason this was not the case. The expert states that he finds it strange that this was not handled more responsibly. More than a year had passed between the end of the experiment and the theft of the computer and in this time it would have been possible to ensure that the information existed in more than one location.

To put matters in perspective, the expert states that it would take something on the scale of a police operation to resolve the issues where a suspicion of misconduct remains, including a thorough scrutiny of travel bookings, credit card use and email traffic.

After this opinion, the Board obtained additional information in the case of the type the expert had called for, particularly relating to Lönnstedt's presence on Gotland and her travel to and from Gotland, but also relating to the time when the microplastic particles used became available. After this information had been made available, the expert made a supplementary statement clarifying his previous response that the experiments described in the article could not have been carried out in the time available.

9. The Board's assessment

The Board has to take a position on whether misconduct in research has occurred in the research project, in the form of falsification and fabrication and failure to obtain approval. The issues that the Board has examined in detail concern the ethical approval for animal experimentation, the conduct of the experiments and research data. The research data issues are discussed in two sections, namely, making published research data available and preservation of research data.

9.1 Ethical approval for animal experimentation

The Board finds that the evidence shows that the experiments on which the article in Science was based were conducted without the existence of approval as prescribed in the Animal Welfare Act (1988:534).

In a statement to the Board, the Uppsala Ethical Committee on Animal Experiments states as follows:

Peter Eklöv's application C 59/15, entitled "Environmental impacts on behavioural and morphological variation in fish populations", was received by the Ethical Committee on Animal Experiments on 29 April 2015. The application shows that it was signed by the applicant Peter Eklöv and the responsible supervisor on 28 April 2015. The Committee's Preparatory Group 3 processed the application and, having asked the applicant to respond to a number of questions (supplementary information), recommended approval of the application in its minutes dated 13 May 2015. The application was then taken up at the Committee's plenary session on 29 May 2015, at which a decision on the application was postponed and the applicant was asked to contact the chair of the Preparatory Group, Mats Nilsson, to answer additional questions before a decision was taken. Preparatory Group 3 obtained further supplementary information from the applicant and once again recommended approval of the application, in its minutes dated 8 June 2015. The application was then taken up at the Committee's plenary session on 26 June 2015, at which it was approved and the applicant received permission to carry out the experiment, as modified by the supplementary measures taken. The Committee's decision reveals that the severity of the experiment was classified as considerable and that the experiment was to be evaluated afterwards. The approval is valid for the period 26 June 2015 to 26 June 2020. The decision was sent to the applicant by post in a message dated 3 July 2015. It is unclear when the message was dispatched. According to

the signed receipt of service, the applicant, Peter Eklöv, was served with the decision on 17 July 2015.

Even if the application had not needed to be supplemented, approval would not have been ready at the time when the experiments concerned were carried out, i.e. a period ending around 15 May. It is therefore clear that Lönnstedt and Eklöv did not have an approved ethical application for animal experimentation when the experiment was conducted, as they claim in the article. Moreover, the application for ethical approval for animal experimentation does not cover all the research that was subsequently conducted, such as experiments involving predators.

It is highly probable that Lönnstedt and Eklöv have committed offences against the Animal Welfare Act. The expert explicitly points out that the application for ethical approval for animal experimentation differs in several respects from the experiments reported in the article in *Science*: the animal collection sites, the facility where the experiments were conducted and the design of the experiments. The Board's assessment is that the claim in the article, "*All work reported herein was conducted in accordance with the guidelines for the care and use of animals in research of the Swedish Board of Agriculture with approval by the Uppsala University Ethics Committee*", is not true. The Board also considers that this claim was formulated in the awareness that its substance was not compatible with the true circumstances, and that this was therefore done intentionally.

Who is responsible?

During the investigation, Lönnstedt has stated that she herself was not involved in the application for ethical approval for animal experimentation and that she was used to different procedures from her time in Australia, where she had received her entire doctoral education. It therefore never occurred to her to personally check the ethical approval. However, an email from Lönnstedt from 27 April 2015, i.e. the day before the application for ethical approval was submitted, mentions a "load of fuss about ethical approval". This shows that Lönnstedt was aware that there were problems with the application.

Eklöv was the one who applied for approval. Both he and Lönnstedt state that Lönnstedt conducted the experiments; Eklöv did not participate physically at any time at Ar Research Station. Even if Eklöv did not participate in the actual conduct of the experiments, it was he who applied for approval for animal experimentation and an applicant has a responsibility to check that what is written in the application is followed.

The Board considers that both the authors are responsible for the fact that the research was carried out without the existence of such approval.

9.2 Making published research data available

The Board considers that the respondents have attempted to publish research data and have therefore not deliberately avoided making research data available in connection with publication.

The article in *Science* contains the claim: “*The data reported in this paper are archived at the research database at Uppsala University and are also included in the online supplementary materials.*”

Excerpts from the log from the DiVA helpdesk (Uppsala University’s database for publication and registration of publications) show that Lönnstedt contacted the database helpdesk on 22 April 2016, writing as follows:

Peter Eklöv and I (both from the Evolutionary Biology Centre, Limnology) have just had an article accepted by Science and we need to make our data available, so DiVA would be perfect. We were thinking of including a statement in the manuscript reading:

“The data reported in this paper are archived at the DiVA research database at Uppsala University, and are also included in the online supplementary materials.”

Could you help me upload it? I have attached 2 PDF files containing behavioural data...”

She received a confirmatory reply to this request. Furthermore, she contacted the same helpdesk on 10 June, i.e. a week after the article had been published and also a week after an international colleague had enquired about data. Her request was then as follows:

“I was hoping you could help me with something in connection with the matter below. When we were last in touch, you got the wrong files for our new manuscript. All that’s missing is the raw data for ‘proportional change in predator responses’. I’ve now seen to it that the data are in graph form and this is attached. Could you upload it (and remove the other files) and make the data available by next Monday?”

The DiVA helpdesk states that the files were published on 13 June 2016, i.e. the day after Lönnstedt’s computer containing original data was reported stolen. The Board has examined all the files and notes that the files sent to the DiVA helpdesk are also in the supplement to the article in *Science*.

The Board does not consider that the evidence shows that Lönnstedt neglected to archive data from the article in Uppsala University’s research database. It is worth adding that *Science* accepted the data provided by Lönnstedt.

9.3 Preservation of documentation

The Board considers that the evidence shows that Lönnstedt did not take adequate measures to ensure the preservation of research data. Her conduct displays gross negligence but was not committed intentionally.

The Board considers that a key question in the investigation concerns the responsibility of researchers to document their experiments to facilitate external review. Another key question is the extent to which the absence of documentation in itself constitutes misconduct and can be deemed to come under the concept of falsification. The meaning of the terms ‘falsification and fabrication’ cannot be interpreted solely on the basis of

Uppsala University's guidelines; the Board also has to take account of how the national and international research communities interpret these concepts.

In its document *Good Scientific Practice*, the Swedish Research Council has the following to say about falsification:

Falsification, however, is a more multifaceted phenomenon. The concept comprises all the possible ways of manipulating the research process, equipment, material or data that make it impossible to present a research project in a trustworthy way. The same can happen if certain data or experiments are left out of the report. It is also possible to manipulate the research report itself, for instance through changing diagrams and other pictures. New technology has made manipulation increasingly easier.

The Board therefore has to decide whether the absence of adequate documentation and saving of such documentation is a measure that “*make(s) it impossible to present a research project in a trustworthy way*”. If this is the case, the question that this investigation has to address is whether this can be considered to have occurred intentionally. The lower threshold for what qualifies as intention in the interpretation of Swedish law is what is known as “intention through indifference” (*likgiltighetsuppsåt*; see *Nytt juridiskt arkiv* [New Legal Archive] 2004, p. 176).

The Board has investigated the back-up procedures in existence at the department at the relevant time. According to the department's computer support unit, Lönnstedt had received a laptop computer from Uppsala University in connection with her appointment. Everyone who is employed at the department has their own folder on the department's own central file server and access to the department's shared storage facility. These storage facilities/folders are automatically backed up to the University's central back-up system. An examination of the contents of the server and the back-up of Lönnstedt's folder revealed that they were empty, which means that Lönnstedt has never used her folder on the server. The routine at the department is that researchers themselves must make sure to use the resource offered by the server, either by working on the server or by copying material to it. The server is available via the local network or by using a VPN. Lönnstedt has not had a VPN connection (a special network connection to the University's network) for her computer. The Limnology Division at the time was running a trial project in which some researchers had a ‘folder redirection’ system, which means that the ‘Documents’ folder on the local computer is not actually on a local drive but is in the user's folder on the server. However, this did not involve everyone at the division and it did not involve Lönnstedt. Eklöv's computer, on the other hand, was set up in this way. Apparently there were problems with local storage and, particularly before 2015, there was a temporary shortage of storage capacity. Users affected by this were informed directly at times when back-up could not be completed. The department's computer support unit states that there are no contact mails from Lönnstedt during the time period concerned indicating that she had difficulties connecting to the server. They state that they were in contact with Lönnstedt on several occasions, but only about purchases or software installation.

There is therefore no indication that Lönnstedt attempted to find out how her computer should be backed up to Uppsala University's servers. Nor is there any indication that

she actively attempted to try out the server system and the way it functioned, or that she tried to use the server system for storage. This applies to the entire period from November 2014 (when her computer was purchased) onwards, during the time when the experiments in question were done in May 2015, and during the subsequent period up to and including June 2016, when the article in *Science* was published.

In the Board's view, measures to ensure secure documentation of all stages of research and of the data produced in research are an essential part of the research process. Several server systems are available at Uppsala University for the benefit of the University's researchers. This does not mean that use of these resources is the only acceptable solution for secure storage of research data. Non-digital solutions and other types of digital storage that in themselves ensure that basic security requirements are satisfied have the same function and are acceptable.

Lönnstedt did not ensure effective back-up of the raw data underlying the article in *Science*. The Board finds that the absence of adequate documentation and saving of such documentation have made it impossible to present the research in a reliable way. The question then is whether this, by objective standards, comes under the definition of falsification and fabrication. The rules applying to the US research community and introduced by the Office of Research Integrity indicate that this could be the case. They state the following:

...

Sections 93.106 and 93.516 have been changed to state that the destruction, absence of, or respondent's failure to provide records adequately documenting the questioned research is evidence of research misconduct where the institution or HHS establishes by a preponderance of the evidence that the respondent intentionally, knowingly, or recklessly had research records and destroyed them, had the opportunity to maintain the records but failed to do so, or maintained the records, but failed to produce them in a timely manner, and that respondent's conduct constitutes a significant departure from accepted practices of the relevant research community. This is in keeping with the definition of falsification to include omitting data or results such that the research is not accurately represented in the research record (Sec. 93.103(b)) and with the requirements for a finding of research misconduct in Sec. 93.104.

...

§ 93.516 Standard and burden of proof.

(b) Burden of proof. (1) ORI bears the burden of proving the findings of research misconduct. The destruction, absence of, or respondent's failure to provide research records adequately documenting the questioned research is evidence of research misconduct where ORI establishes by a preponderance of the evidence that the respondent intentionally, knowingly, or recklessly had research records and destroyed them, had the opportunity to maintain the records but did not do so, or maintained the records and failed to produce them in a timely manner and the

respondent's conduct constitutes a significant departure from accepted practices of the relevant research community.

Fed Regist.2005 May 17;70(94):28369-400.

In the light of what has been stated above, the Board takes the view that the absence of raw data in itself is a circumstance that can come under the concept of falsification and fabrication. The question then is whether the failure to present raw data should be deemed to have occurred intentionally or through gross negligence.

As is apparent from the section on storage of published research data, Lönnstedt made active attempts to ensure that research data were saved and made available. She was by no means indifferent to the need for data to be available to underpin her research results. Intention through indifference or other intention to withhold or not ensure the availability of raw data cannot be deemed to have existed.

However, in view of the importance that the research community attaches to the availability of raw data, so as to be able to verify and check research findings, and for other reasons, Lönnstedt's failure to ensure that back-up existed for her raw data must be regarded as grossly negligent.

With the guidelines that now apply to allegations of misconduct, gross negligence would be enough for Lönnstedt to be considered guilty of misconduct in research on the grounds of an absence of raw data. However, as previously mentioned, different liability rules applied at the time when Lönnstedt and Eklöv's research was in progress. Under the guidelines that were in force at the time, liability required intention – there was no liability for misconduct in research in the case of gross negligence.

The Board finds that Lönnstedt should not be considered guilty of misconduct in research on the grounds of an absence of raw data.

9.4 Conduct of the experiments

The Board is of the opinion that the experiments cannot have been conducted as described in the article. Consequently, the published results are fabricated.

The Board considers the timeline for the conduct of the experiments extremely important, since it is essential that what is reported in the article could have been carried out in temporal terms during the period when the lead author, Lönnstedt, was present at the experimental station on Gotland. In the absence of a timeline for the research project drawn up by Lönnstedt, the Board has studied Lönnstedt's presence at Ar on Gotland on the basis of Lönnstedt's own emails sent in the University's email system, travel documentation from Uppsala University and the Royal Swedish Academy of Sciences, and receipts submitted by Lönnstedt herself in the course of the investigation (*appendix 2*). Lönnstedt has examined the timeline drawn up by the Board. Judging by the position she takes, she considers it inaccurate but she has not submitted any factual information to support an alternative assessment.

The Board's investigation shows that Lönnstedt was present on Gotland, beginning on 7 April, as follows: initially 4 days on Gotland, followed by 2 days on the mainland, then 9 days on Gotland, followed by 12 days on the mainland. On 4 May, the day on which the investigation has shown that Lönnstedt had access to plastic particles, the experiments involving exposure to plastic particles began. Lönnstedt was then on Gotland for 5 days, followed by 2 days on the mainland, and was finally present on Gotland for 4 days. This information must be compared with the sections in the main text and supplement to the article specified below.

Main text

*To assess direct chemical effects of polystyrene microplastics on fish, we collected fertilized egg strands of *P. fluviatilis* from natural populations in the Baltic Sea and placed them in 1000-ml glass aquaria that contained one of the three microplastic concentrations and filtered estuarine water (19). We then monitored the number of successful hatching events over a 3-week period.*

Science article, main text, page 1214, right-hand column

To assess more direct ecological effects of microplastic exposure on fish, we measured individual survival rates of 2-week-old larvae from the different treatments when exposed to a natural and common predator....

Science article, main text, page 1215, right-hand column

Two weeks after hatching, total length (mm) differed significantly between fish exposed to the different microplastic concentrations

Science article, main text, page 1215, right-hand column

Supplement

Hatching events (defined as the number of larvae that successfully hatched out of eggs over a 3-week period) were monitored daily, and immediately after hatching larvae were transferred to new aerated 1000mL aquariums (densities of 15-25 larvae per aquaria), containing one of the three different microplastic particle concentrations.

Science supplement, bottom of page 2 and top of page 3

*Larval perch were reared for a total of 2 weeks, and fed freshly hatched free-swimming *Artemia nauplii* twice daily...*

Science supplement, page 3, line 17

*Predator-induced mortality rates were compared among 2-week old *P. fluviatilis* larvae from the three different microplastic treatments.....*

Science supplement, page 6, line 6

*After 2 weeks 20 randomly chosen *P. fluviatilis* were removed from the treatments and photographed...*

Science supplement, page 7, line 15

The experiments reported in the article presuppose exposure to plastic particles. The earliest date on which this could begin was 4 May, when the particles became available to Lönnstedt. The experiments were to continue for a period of three weeks. This could not have happened, as Lönnstedt's presence at the research station was limited to 9 days during the period from 4 May until 14 May, when she left Gotland. This means that the experiments could not have been conducted during the time that Lönnstedt was present at the experimental facility at Ar on Gotland. One consequence of this conclusion is that the main experiments on which the article is based and which presuppose observation for three weeks after exposure to plastic particles were not actually conducted. Consequently, the published results are fabricated, i.e. misconduct has occurred. The Board considers that Lönnstedt must have been aware of this when she formulated the text of the article.

The Board cannot express an opinion on the extent to which experiments were conducted at all, an issue that is incidental in this connection. There are strong indications that certain experiments were actually performed, but not in the way described in the article.

Who is responsible?

The Board's investigation shows that Lönnstedt planned and conducted certain experiments on Gotland. She was aware that the experiments had not been conducted in the manner and to the extent reported in the article, which means that she has intentionally fabricated the information and has thereby committed misconduct in research. Eklöv participated in planning and discussions, but was never present when the experiments were physically performed on Gotland. In the Board's opinion, Eklöv, in his capacity as co-author, senior researcher and supervisor, had a responsibility to check that the account in the research article agreed with the research that had been conducted. However, his failure in this respect cannot entail liability for misconduct in research, given the requirement of intention that applied at the time when the article was published.

10. Conclusion

On the basis of Uppsala University's former guidelines on the procedure for handling alleged misconduct in research, and the definition of misconduct in the guidelines, the Board's assessment is that the respondents, Oona Lönnstedt and Peter Eklöv, are guilty of misconduct in research. Eklöv has committed misconduct in research by violating the regulations on ethical approval for animal experimentation. Lönnstedt has committed misconduct in research by violating the regulations on ethical approval for animal experimentation and by reporting results from experiments that cannot have been carried out, which means that the results reported are fabricated.

The Board finds that the circumstances in the case warrant a general recommendation to the Vice-Chancellor to review the formal requirements Uppsala University makes of its employees regarding the preservation of documentation of the conduct and results of research.

On behalf of the Board for Investigation of Misconduct in Research

Erik Lempert
Chair

Bengt Gerdin
Rapporteur

TRANSLATION

31 August 2016

UFV 2016/1074

Dean Johan Tysk
Faculty of Science and Technology
Uppsala University

Preliminary investigation of accusation of research misconduct

Background

The accusation (dated 20 June 2016) concerns research misconduct in a study by researchers at Uppsala University, published in the journal *Science* on 3 June 2016:

Lönnstedt, O.M. and Eklöv, P. (2016), Environmentally relevant concentrations of microplastic particles influence larval fish ecology, *Science* 352, pp. 1213–1216.

The accusation was submitted by: F. Jutfelt, J. Sundin, D. Roche, G. Raby, B. Speers-Roesch, S. Binning and T. Clark.

Dr Oona Lönnstedt is a postdoctoral research fellow at the Department of Ecology and Genetics, BMC, Uppsala University. Professor Peter Eklöv is her supervisor and project manager.

On 5 July 2016 the Dean of the Faculty of Science and Technology entrusted the following experts with the task of undertaking the preliminary investigation (UFV 2016/1074):

Professor Birgitta Bergman, Stockholm University; Professor Per Jensen, Linköping University; and Magnus Hallberg, Legal Officer, Uppsala University.

The experts have no conflicts of interest or other disqualifying relationship with the accused or the accusers.

The accusations made in points 1–4 in the document submitted on 20 June 2016 by Jutfelt et al., and in supplementary submissions from these persons (excerpts from email and other correspondence, specification of the sequence of events, photographs, etc.), have been thoroughly examined in the confidential preliminary investigation. Lönnstedt and Eklöv have been given the opportunity to respond in writing to the accusations (points 1–4) and to a number of supplementary questions (20 points, by mail, 16 June 2016) from the accusers, and to make further clarifications requested by the investigators. All communication with both parties has been in writing.

The investigators' assessment of the complaint

In their complaint to Uppsala University, Jutfelt et al. state that they base their suspicions of misconduct on four distinct points. The experts have taken a position on each of these points separately.

(1) Firstly, the complainants consider that the article in *Science* contains several deficiencies of execution and reporting. They point out a lack of raw data, which the text of the article states is available in the 'supplementary materials' accompanying the *Science* article and archived in the

research database at Uppsala University. In addition, the existence of ethical approval for animal experiments is questioned.

The investigating committee finds that these observations were correct, but according to the information obtained by the experts this was due partly to the failure of Science to enter these data prior to publication, as a result of a misunderstanding, and partly to apparent shortcomings in the storage of research data at the Department of Ecology and Genetics, not to their being actively withheld by the accused. However, the authors compensated for this by sending additional data to the editor of the journal and, by mail, to the complainants. All necessary raw data has been freely available to readers for some time, in supplementary data published by Science. Ethical approval has also been obtained.

This point is therefore deemed to have been remedied and consequently research misconduct cannot be deemed to have occurred.

(2) Secondly, reporting problems are pointed out in the publication, concerning the execution of the experiments on which the article is based, e.g. sample size and duration of exposure.

The investigators find that there appears to be some lack of clarity or some carelessness in the description of the procedure in the article in Science. The experiments described in an article should be sufficiently clear that other researchers can repeat the experiments. On the other hand, the amount of space available in these prestigious journals is so limited that it is often impossible to include all details. The accused have provided a number of clarifications and elaborated on the description of the procedure in a highly satisfactory manner, and the complainants have also received this additional information. The investigators find no evidence that the authors have deliberately and intentionally attempted to mislead or conceal anything relating to the execution of the experiment. The complainants should therefore be able to repeat the experiment without difficulty, which was the purpose of the complaint, in particular following the accused's detailed responses to the 20 supplementary and specific questions concerning the execution of the experiment.

The investigators find the authors' responses highly credible and research misconduct can therefore not be deemed to have occurred with respect to this point.

(3) Thirdly, the complainants cite concerns about the statistical processing and analysis of data obtained in the experiments.

With regard to methodology in behavioural studies and statistical analysis, this is clearly described in the article and has been further clarified by the accused in their response to the complainants. It is normal in research processes that different researchers have different views on details of methodology and analysis, but needless to say this has nothing to do with research misconduct. In this respect, moreover, it has to be assumed that Science has rigid and thorough review processes, including statistics experts who do not appear to have had any objections to the statistics published. With regard to this point no research misconduct has therefore occurred.

(4) Fourthly, it is claimed that there are substantial differences between the manner in which the experiments were executed according to the article in *Science*, and how they were actually executed, based on 'eye witnesses' who are not named. Appendices to the complaint refer to reports from witnesses and two photographs that are claimed to prove the suspicions. The problem areas raised concern duration of exposure, number of replicates in terms of the size of the experimental vessels, number of fish, etc.

These accusations have been thoroughly answered and explained in the written document with the 20 questions mentioned above, which address these specific aspects. The investigators find that they have been answered in a satisfactory and credible manner. The photographs cited appear to represent a different experiment than the one reported in the article in Science, and in other respects the investigators find that the witness statements are imprecise and certainly do not constitute incontrovertible evidence that any deliberate misconduct occurred in the research conducted.

Further comments from the investigators

The investigators note that Jutfelt et al. appear to have a very strong desire that the article be examined for research misconduct, but that the large majority of their objections come within the ambit of normal scholarly discussion, which could have been conducted directly with the authors of the article. The most serious accusations, which could potentially indicate misconduct, concern assertions that the experiments were not executed as asserted, and that Lönnstedt and Eklöv thus fabricated their data. The investigators have not found any evidence that this was the case.

However, the investigators note inadequate documentation of the research on the part of the accused, with necessary documentation only stored on one computer (which was subsequently stolen, as confirmed by the report of the theft to the police), and with a lack of back-up storage at Uppsala University. However, this cannot be judged to be a sign of any research misconduct.

Conclusion

To sum up, based on the guidelines and definitions in Section 1 concerning research misconduct (adopted by the Vice-Chancellor of Uppsala University, UFV 2010/664), and a comprehensive review of all the material submitted by the accusers and the accused (UFV 2016/1074), the investigators find no evidence of research misconduct in the article by Lönnstedt and Eklöv published in *Science* (3 June 2016) to which the accusers refer.

Since there is insufficient reason for a full investigation, we recommend Uppsala University not to carry out any further investigation and instead, in accordance with the guidelines in Section 8, to take diligent steps to restore the reputation of the accused.

Date as above,

[signature]

Birgitta Bergman, professor

Stockholm University

[signature]

Per Jensen, Professor

Linköping University

[signature]

Magnus Hallberg, Legal Officer

Uppsala University

The Board's timeline

G means presence on Gotland

S/U means presence on the mainland, mainly in Stockholm or Uppsala

- G** Tuesday 7 April: OL flew to Gotland (air ticket).
- G** Wednesday 8 April: no information
- G** Thursday 9 April: purchases at Rusta in Visby, as shown by copies of receipts.
- G?** Friday 10 April: no information at present
- S/U** Saturday 11 April, 11:36: statement in own email: "I'm off to a birthday party at Sturebadet now but plan to go to Haga Park ... tomorrow"
- S/U** Sunday 12 April
- G** Monday 13 April, 09:18: receipts from Shell, Visby, show that OL is back on Gotland.
- G** Tuesday 14 April: OL sends email to Peter Eklöv from Gotland (Tues 14 April 2015, 13:34)
- G?** Wednesday 15 April: no information at present
- G** Thursday 16 April: OL sends email to Eklöv from Gotland. Receipt from Shell in Visby. Roswald to Gotland
- G** Friday 17 April, 13:51: OL communicates by email with Gunilla Rosenquist on Gotland
- G** Saturday 18 April: spent in Visby, as shown by photo (IMG 5). There are also receipts from Visby
- G** Sunday 19 April: bank account statement shows that purchases were made at Clas Ohlson in Visby
- G** Monday 20 April: her own email shows that OL was on Gotland (Mon 20 April 2015, 09:39)
- G** Tuesday 21 April: purchases made at Kronans Apotek in Visby at 14:21, as shown by receipts.
- S/U** Wednesday 22 April: flies to Arlanda in the morning. (email Tues 21 April 2015, 11:36)
- S/U** Thursday 23 April: OL planned to collect the plastic particles at the Evolutionary Biology Centre (email, Mon 20 April 2015, 10:27); they had not arrived (email, Mon 27 April 2015, 13:44).
- S/U** Friday 24 April: OL had a meeting at the Royal Swedish Academy of Sciences in Stockholm (email 23 April 2015, 14:38)
- S/U** Saturday 25 April: obviously S/U; interpreted from email Mon 27 April 2015, 13:44.
- S/U** Sunday 26 April: obviously S/U; interpreted from email Mon 27 April 2015, 13:44.
- S/U** Monday 27 April: planned meeting with Peter Eklöv (email Fri 24 April 2015, 11:39). Mainland. Postpones plan to return to Gotland on 28 April (own email Mon 27 April 2015, 13:44). "I will not be flying to Gotland tomorrow like I thought. The microplastics haven't arrived and I need to go see a doctor so I will likely not be back on the island until next week (if then)."
- S/U** Tuesday 28 April: mainland (own email Mon 27 April 2015, 13:44).
- S/U** Wednesday 29 April: in Uppsala (own email Wed 29 April 2015, 10:43). Indicates plan to travel to Stockholm and then return to Uppsala on Sunday (3 May).
- S/U** Thursday 30 April, 10:26: own email indicates OL is not on Gotland.
- S/U** Friday 1 May: not on Gotland (Mon 4 May 2015, 14:31)
- S/U** Saturday 2 May: not on Gotland (Mon 4 May 2015, 14:31)
- S/U** Sunday 3 May: not on Gotland (Mon 4 May 2015, 14:31)

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G	Monday 4 May: OL flies to Visby in the morning, as shown by email and receipts from taxi and Shell
G	Tuesday 5 May: OL sends email to Eklöv informing him that the experiments have started (Tues 5 May 2015, 14:34).
G	Wednesday 6 May: working at Ar
G	Wednesday 7 May: working at Ar
G	Friday 8 May. Air ticket to Arlanda, departure date 8 May.
S/U	Saturday 9 May. Air ticket to Arlanda, departure date 8 May.
S/U	Sunday 10 May. Air ticket to Arlanda, departure date 8 May.
G	Monday 11 May: OL returns to Visby by air and takes a taxi to the flat in Visby at lunchtime. OL writes in two email messages (Mon 11 May, 10:03 and 10:06): "Hope this will be my last week at AR" and "Hope this will be my last week on Gotland". The same evening (Mon 11 May 2015, 16:38) OL writes in an email: "This particular week I'm down on Gotland but coming up to Stockholm next weekend if you feel like talking more." ("Next weekend" means Sat-Sun 16-17 May/Board's note).
G	Tuesday 12 May: no information.
G	Wednesday 13 May, 10:07: Lönnstedt writes in another email: "I'm on Gotland finishing the experiments. Very exciting results." Her presence on Gotland is also confirmed by her bank account statement.
G	Thursday 14 May: bank account statement shows a payment to EJMUNDS GÅRD, ROMAKLOSTER. Travel home from Gotland on 14 May, 16:40, according to Royal Swedish Academy of Sciences
	Friday 15 May. Travel home from Gotland occurred on 14 May, according to Royal Swedish Academy of Sciences
	Saturday 16 May. Travel home from Gotland occurred on 14 May, according to Royal Swedish Academy of Sciences
	Sunday 17 May. Travel home from Gotland occurred on 14 May, according to Royal Swedish Academy of Sciences
	Monday 18 May: Travel home from Gotland occurred on 14 May, according to Royal Swedish Academy of Sciences
S/U	Tuesday 19 May, 09:26: Lönnstedt writes to Eklöv: "Are you in today? Would be fun to drop by and talk a bit about results!" This is interpreted as having been written in Uppsala. Email on Wednesday 20 May, 16:16, confirms that the meeting with Eklöv occurred. Anders Nissling confirms that Lönnstedt left Ar no later than the morning of 19 May.
S/U	Wednesday 20 May, 10:51: Lönnstedt writes in an email: "Now back in Uppsala/Stockholm..." She also writes in another email: "This past weekend I was busy Friday and then free the rest of the weekend." (Wed 20 May 2015, 11:26), and in another email the same day, 16:16: "...I'm back in Stockholm and as always it's really hectic here. I was in Uppsala Tuesday day and met up with Peter...." ("Tuesday" was 19 May)
S/U	Thursday 21 May: all OL's research material is gone from the station, according to witness account from Gunilla Rosenqvist.

In conclusion, OL can be seen to have been on Gotland (beginning 7 April) as follows:

Gotland	3 days
Stockholm/Uppsala	2 days
Gotland	9 days
Stockholm/Uppsala	12 days
Gotland	5 days (including the start of the exposure experiments)

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Stockholm/Uppsala	2 days (during this time colleagues carried out limited management of the experiments)
Gotland	4-8 days