



UNIVERSITY OF
GLOUCESTERSHIRE

This is a peer-reviewed, post-print (final draft post-refereeing) version of the following published document:

**Hart, Adam G ORCID: 0000-0002-4795-9986, Stafford, Richard, Smith, Angela L. and Goodenough, Anne E ORCID: 0000-0002-7662-6670 (2010) Evidence for contemporary evolution during Darwin's lifetime. *Current Biology*, 20 (3). R95.
doi:10.1016/j.cub.2009.12.010**

Official URL: <http://dx.doi.org/10.1016/j.cub.2009.12.010>

DOI: <http://dx.doi.org/10.1016/j.cub.2009.12.010>

EPrint URI: <https://eprints.glos.ac.uk/id/eprint/3333>

Disclaimer

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.

This is a peer-reviewed, post-print (final draft post-refereeing) version of the following published document:

Hart, Adam G. and Stafford, Richard and Smith, Angela L. and Goodenough, Anne E. (2010). *Evidence for contemporary evolution during Darwin's lifetime*. Current Biology, 20 (3), R95. ISSN 09609822

Published in Current Biology, and available online at:

<http://www.sciencedirect.com/science/article/pii/S0960982209021290>

We recommend you cite the published (post-print) version.

The URL for the published version is <http://dx.doi.org/10.1016/j.cub.2009.12.010>

Disclaimer

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT

Submitted as a Correspondence to *Current Biology*

Evidence for contemporary evolution during Darwin's lifetime

Adam G. Hart^{1*}, Richard Stafford¹, Angela L. Smith², and Anne E. Goodenough¹

1. Department of Natural and Social Sciences, University of Gloucestershire, Cheltenham, UK, GL50 4AZ
2. Gloucester City Museum & Art Gallery, Brunswick Road, Gloucester, GL1 1HP

* Correspondence Author

Darwin's *On the Origin of Species* [1] introduced the world to the most fundamental concept in biological sciences - evolution. However, in the 150 years following publication of his seminal work, much has been made of the fact that Darwin was missing at least one crucial link in his chain of evidence – he had no evidence for contemporary evolution occurring through natural selection. Indeed, as one commentator noted on the centenary of the publication of *Origin*, “Had Darwin observed industrial melanism he would have seen evolution occurring not in thousands of years but in thousands of days - well within his lifetime. He would have witnessed the consummation and confirmation of his life's work” [2].

The case of the peppered moth (*Biston betularia*) and industrial melanism is, despite some recent controversies [3], often regarded as the clearest example of natural selection in action [2]. In this case, natural selection acts to increase the frequency of melanic genotypes and phenotypes through decreased depredation of these darker forms in habitats affected by industrialisation. While evidence of increasing frequency of melanic forms in the Lepidoptera was available during Darwin's lifetime, the first observations

being in 1848 [4], current understanding is that it was not until 14 years after Darwin's death that Tutt [5] explicitly linked melanism with natural selection [3]. Industrial melanism has thus been seen as a post-Darwin confirmation of contemporary evolution, while Darwin's work is viewed as the solving of a historical puzzle without contemporaneous evidence.

A recent examination of Darwin's correspondence indicates that melanism in the Lepidoptera had been linked to natural selection prior to Tutt, and also that Darwin himself had been made explicitly aware of this. Albert Brydges Farn, a British entomologist (1841-1921), wrote to Darwin on the 18th November 1878 to discuss his observation of colour variations in the Annulet moth, (a Geometer moth, then *Gnophos obscurata*, now *Charissa obscurata*). In the letter, Farn [6] indicates different colour morphs, describing how each is matched to the habitats in which they are found (dark morphs on peat, white morphs on chalk cliffs) and refers explicitly to this variability as being "*variations [that] point to the survival of the fittest [Spencer's synonym for natural selection]*".

He goes on to link natural selection to industrial melanism, indicating anecdotal evidence of the decrease in frequency of light morphs on chalk slopes in Lewes, Sussex, UK, following industrial activity and the collection of dark morphs from chalk cliffs in the New Forest, Hampshire, UK. He notes:

"It is a curious fact, in connexion [sic] with these dark specimens [from chalk cliffs in the New Forest], that for the last quarter of a century the chalk slope, on which they occur, has been swept by volumes of black smoke from some lime-kilns situated at the bottom: the herbage, although growing luxuriantly, is blackened by it. I am told, too, that the very light

specimens are now much less common at Lewes than formerly, and that, for some few years, lime-kilns have been in use there”.

Eighteen years prior to Tutt, Farn puts together the pieces of the puzzle and formulates the essence of the theory of industrial melanism, much as we understand it today.

Unfortunately it appears that Darwin did not realise the significance of this information; certainly there is no evidence that he replied to Farn. However, while Tutt is well credited for his work on industrial melanism in the Lepidoptera, credit too should be given to Farn. Not only does Farn's work provide evidence to support the selective advantage of melanism, but the phenomenon he describes also appears to be the first documented record of contemporary evolution.

References

1. Darwin, C.R. (1859). *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life.* (London: John Murray).
2. Kettlewell, H.B.D. (1959). Darwin's missing evidence. *Sci. Am.* **200** (March) 48-53.
3. Majerus, M.E.N., (1998). *Melanism: evolution in action.* (Oxford: Oxford University Press).
4. Edleston, R.S. (1864). *Amphydaris betularia.* *Entomologist* **2**, 150.
5. Tutt, J.W. (1896). *British Moths.* (London: Routledge).
6. Farn, A.B. (1878). Farn, A.B. to Darwin C.R. 18 Nov 1878, Darwin Correspondence Project Letter 11747, held as **DAR 164:26** as part of The Darwin Papers, Manuscripts Room, Cambridge University Library, West Road, Cambridge, England. A transcript will be available online through the Darwin Correspondence Project [NOTE – this has been checked to publication standard by the CUL, contact: Mrs Rosemary Clarkson, Darwin

Correspondence Project +44 (0)1223 333008]. We thank the Editors of the Darwin Correspondence Project for access to unpublished material.

The authenticated transcript is presented below – this will appear online through the Darwin Correspondence Project.

From Albert Brydges Farn
18 November 1878
The Dartons, Dartford, Kent.

My dear Sir,

The belief that I am about to relate something which may be of interest to you, must be my excuse for troubling you with a letter.

Perhaps among the whole of the British Lepidoptera, no species varies more, according to the locality in which it is found, than does that Geometer, *Gnophos obscurata*. They are almost black on the New Forest peat; grey on limestone; almost white on the chalk near Lewes; and brown on clay, and on the red soil of Herefordshire.

Do these variations point to the "survival of the fittest"? I think so.

It was, therefore, with some surprise that I took specimens as dark as any of those in the New Forest on a chalk slope; and I have pondered for a solution. Can this be it?

It is a curious fact, in connexion with these dark specimens, that for the last quarter of a century the chalk slope, on which they occur, has been swept by volumes of black smoke from some lime-kilns situated at the bottom: the herbage, although growing luxuriantly, is blackened by it.

I am told, too, that the very light specimens are now much less common at Lewes than formerly, and that, for some few years, lime-kilns have been in use there.

These are the facts I desire to bring to your notice.

I am, Dear Sir,
Yours very faithfully,
A. B. Farn

Provenance DAR 164: 26. Proofread 9 Oct. 09 RAC