

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA, 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.  
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY) 23-12-2015	2. REPORT TYPE Final Report	3. DATES COVERED (From - To) 15-Dec-2010 - 30-Sep-2015
---	--------------------------------	---

4. TITLE AND SUBTITLE Final Report: Oxidative stress, stress resistance, and longevity in Apis mellifera	5a. CONTRACT NUMBER
	5b. GRANT NUMBER W911NF-04-D-0003
	5c. PROGRAM ELEMENT NUMBER 0310BJ

6. AUTHORS Micheline Strand, David Tarpy, Olav Rueppell, Hongmei Li-Byarlay, Ming Huang, Michael Simone-Finstrom	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES North Carolina State University 2701 Sullivan Drive Admin Srvcs III, Box 7514 Raleigh, NC 27695 -7514	8. PERFORMING ORGANIZATION REPORT NUMBER
--	--

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	10. SPONSOR/MONITOR'S ACRONYM(S) ARO
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) 58829-CH-SR.3

12. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited
--

13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.
---

14. ABSTRACT For studies conducted in Years 1 and 2 of this project, thousands of samples have been processed. Year 1 examined variation within colonies and among individuals to identify behavioral markers of stress resistance and the possible genetic underpinnings of oxidative stress, including paternal or maternal effects. In the second field season, we performed experiments in more of a top-down manner, more thoroughly examining how environmental, colony-level factors influence individual longevity, oxidative damage and stress resistance. This is an area that has not been previously examined at this level and will produce a significant amount of information (e.g., how management
---

15. SUBJECT TERMS oxidative stress
---------------------------------------

16. SECURITY CLASSIFICATION OF:	17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Micheline Strand
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU	19b. TELEPHONE NUMBER 919-549-4343

## Report Title

Final Report: Oxidative stress, stress resistance, and longevity in *Apis mellifera*

### ABSTRACT

For studies conducted in Years 1 and 2 of this project, thousands of samples have been processed. Year 1 examined variation within colonies and among individuals to identify behavioral markers of stress resistance and the possible genetic underpinnings of oxidative stress, including paternal or maternal effects. In the second field season, we performed experiments in more of a top-down manner, more thoroughly examining how environmental, colony-level factors influence individual longevity, oxidative damage and stress resistance. This is an area that has not been previously examined at this level and will produce a significant amount of information (e.g., how management practices may directly impact stress levels) that will lead to a host of new questions for future investigation. With the addition of a new postdoctoral researcher, training and optimization of methods occurred in the middle of the fourth field season. For the third field season, we have submitted a manuscript for publication comparing honey bee drones (males) in their susceptibility vs. resistance to oxidative challenge. We have also completed the analysis of the Year 2 samples for the following comparisons: (1) Stationary vs. Migratory vs. Intense Migratory and (2) young In-Hive Workers vs. old Foragers. Three measures of oxidative stress were measured: (1) DNA oxidation, (2) protein carbonyl, and (3) lipid peroxidase. These results are currently being written up for a submission to Scientific Reports.

---

**Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:**

**(a) Papers published in peer-reviewed journals (N/A for none)**

<u>Received</u>	<u>Paper</u>
-----------------	--------------

**TOTAL:**

**Number of Papers published in peer-reviewed journals:**

---

**(b) Papers published in non-peer-reviewed journals (N/A for none)**

<u>Received</u>	<u>Paper</u>
-----------------	--------------

**TOTAL:**

**Number of Papers published in non peer-reviewed journals:**

---

**(c) Presentations**

Li-Byarlay, H., H. F. Boncristiani, M. Strand, D. R. Tarp, and O. Rueppell. (2015). Transcriptomic analysis of lethal IAPV infection in honey bee pupae. ESA Meeting, Minneapolis MN.

Li-Byarlay, H., H. F. Boncristiani, M. Strand, D. R. Tarp, and O. Rueppell. (2015). Transcriptomic analysis of lethal IAPV infection in honey bee pupae. Biology & Genomics of Social Insects Conference, Cold Springs Harbor Laboratory, NY

Li-Byarlay, H., M. H. Huang, M. Strand, D. R. Tarp, and O. Rueppell. (2015). Effects of oxidative stress in the honey bee drones. ABRC Meeting, Tucson AZ.

Li-Byarlay, H., M. Simone-Finstrom, M. Huang, M. Strand, O. Rueppell, and D. R. Tarp. (2014). Effects of honey bee management on oxidative stress and longevity. ESA Meeting, Portland OR.

**Number of Presentations:** 4.00

---

**Non Peer-Reviewed Conference Proceeding publications (other than abstracts):**

<u>Received</u>	<u>Paper</u>
-----------------	--------------

**TOTAL:**

**Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):**

---

**Peer-Reviewed Conference Proceeding publications (other than abstracts):**

<u>Received</u>	<u>Paper</u>
-----------------	--------------

**TOTAL:**

**Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):**

---

**(d) Manuscripts**

<u>Received</u>	<u>Paper</u>
07/21/2014	1.00 Boncristiani, H.F., Evans, J.D., , Chen, Y., , Pettis, J., , Murphy, C., Lopez, DL, , Simone-Finstrom, , M. Strand, M., , Tarpy, D.R., and, Rueppell, O. In vitro infection of pupae with Isareli acute paralysis virus suggests disturbance of transcriptional homeostasis in honey bees ( <i>Apis mellifera</i> ) , PLoS ONE (09 2013)
12/23/2015	2.00 Ming Hua Huang, Michael Simone-Finstrom, Micheline Strand, David Tarpy, Hongmei Li-Byarlay, Olav Rueppell. Honey bee ( <i>Apis mellifera</i> ) drones resistant to paraquat exhibit increased tolerance, not avoidance or repair, of oxidative damage., The Science of Nature (08 2015)
<b>TOTAL:</b>	<b>2</b>

**Number of Manuscripts:**

---

**Books**

Received      Book

**TOTAL:**

Received      Book Chapter

**TOTAL:**

**Patents Submitted**

---

## Patents Awarded

### Awards

None.

### Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
-------------	--------------------------

**FTE Equivalent:**

**Total Number:**

### Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
-------------	--------------------------

Ming Huang 0.00

Mike Simone-Finstrom 0.00

Hongmei Li-Byarlay 0.00

**FTE Equivalent:** 0.00

**Total Number:** 3

### Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	National Academy Member
-------------	--------------------------	-------------------------

David Tarpay 0.00

Olav Rueppell 0.00

**FTE Equivalent:** 0.00

**Total Number:** 2

### Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	<u>DISCIPLINE</u>
-------------	--------------------------	-------------------

Ravi Dixit 50

Jason Brannock 0

Sam Freeze 0

**FTE Equivalent:** 0.50

**Total Number:** 3

### Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: ..... 1.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 1.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 1.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 1.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense ..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: ..... 0.00

### Names of Personnel receiving masters degrees

NAME

**Total Number:**

### Names of personnel receiving PHDs

NAME

**Total Number:**

### Names of other research staff

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
Jennifer Keller	0.00
<b>FTE Equivalent:</b>	<b>0.00</b>
<b>Total Number:</b>	<b>1</b>

### Sub Contractors (DD882)

### Inventions (DD882)

### Scientific Progress

For studies conducted in Years 1 and 2 of this project, thousands of samples have been processed. Year 1 examined variation within colonies and among individuals to identify behavioral markers of stress resistance and the possible genetic underpinnings of oxidative stress, including paternal or maternal effects. In the second field season, we performed experiments in more of a top-down manner, more thoroughly examining how environmental, colony-level factors influence individual longevity, oxidative damage and stress resistance. This is an area that has not been previously examined at this level and will produce a significant amount of information (e.g., how management practices may directly impact stress levels) that will lead to a host of new questions for future investigation. With the addition of a new postdoctoral researcher, training and optimization of methods occurred in the middle of the fourth field season. For the third field season, we have submitted a manuscript for publication comparing honey bee drones (males) in their susceptibility vs. resistance to oxidative challenge. We have also completed the analysis of the Year 2 samples for the following comparisons: (1) Stationary vs. Migratory vs. Intense Migratory and (2) young In-Hive Workers vs. old Foragers. Three measures of oxidative stress were measured: (1) DNA oxidation, (2) protein carbonyl, and (3) lipid peroxidase. These results are currently being written up for a submission to Scientific Reports.

## Technology Transfer

None.