Complexity of the social environment and behavioural plasticity drive divergent gene expression in the brain of ant queens

Fabio Manfredini[1], Carlos Martinez-Ruiz[2], Yannick Wurm[2,2], DeWayne Shoemaker[3], and Mark Brown[4]

[1]University of Aberdeen
[2]Queen Mary University of London
[3]University of Tennessee
[4]Royal Holloway University of London

July 31, 2020

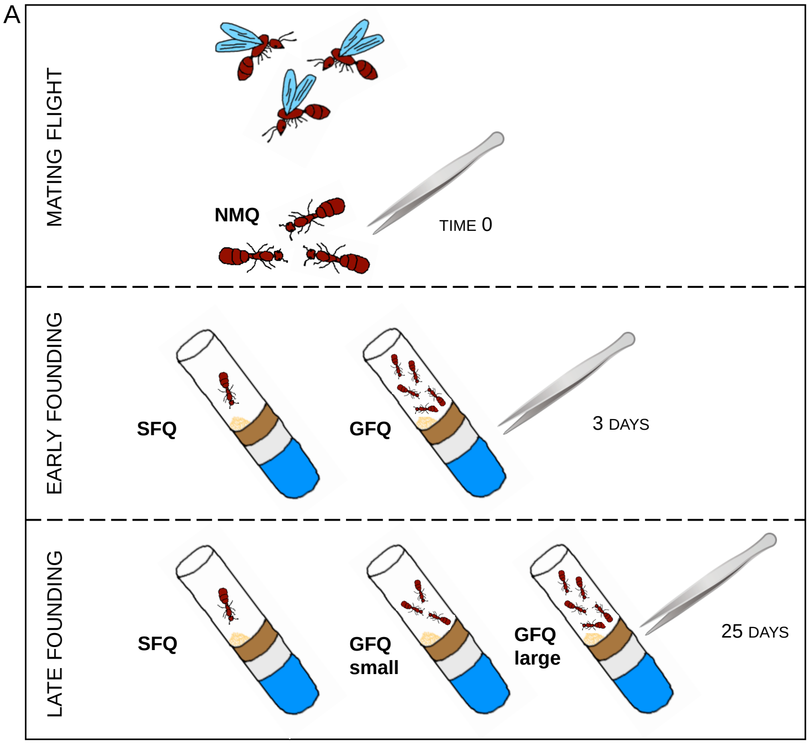
Abstract

Social life and isolation pose a complex suite of challenges to organisms prompting significant changes in neural state. However, plasticity in how brains respond to social challenges remains largely unexplored. The fire ants Solenopsis invicta provide an ideal scenario for examining this. Fire ant queens may found colonies individually or in groups of up to 30 queens. Here, we artificially manipulated availability of nesting sites to test how the brain responds to social vs. solitary colony founding at two key timepoints, and to group size. The difference between group and single founding queens involves only 1 gene when behaviour is still plastic and queens can switch from one modality to another, while hundreds of genes are involved once behaviours are more canalized. Furthermore, we show that large groups lead to greater changes in gene expression than small groups, perhaps due to higher cognitive demands of a more complex social environment.

Hosted file

`FM_manuscript_300720_final.pdf` available at https://authorea.com/users/347652/articles/473272-complexity-of-the-social-environment-and-behavioural-plasticity-drive-divergent-gene-expression-in-the-brain-of-ant-queens

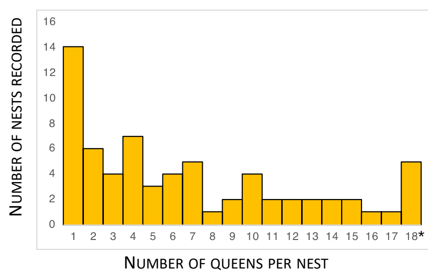
A



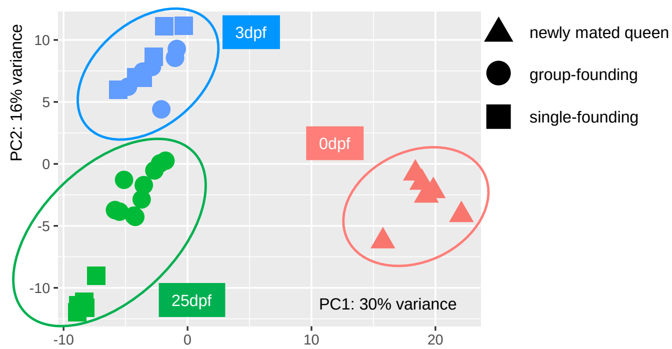
B

		DAY 1		DAY 2	
	TRAY	SINGLE	GROUP	SINGLE	GROUP
LARGE TRAYS	A	1	2	1	2
	B	2	2	0	3
	C	1	2	0	2
	D	1	3	1	3
	E	3	3	2	3
	F	0	2	0	2
	G	1	2	1	2
	TOTAL	9	16	5	17
SMALL TRAYS	A	2	8	0	9
	B	2	4	1	4
	C	0	5	2	5
	D	2	3	2	3
	E	1	5	0	5
	F	2	5	1	5
	G	1	5	3	5
	TOTAL	10	35	9	36

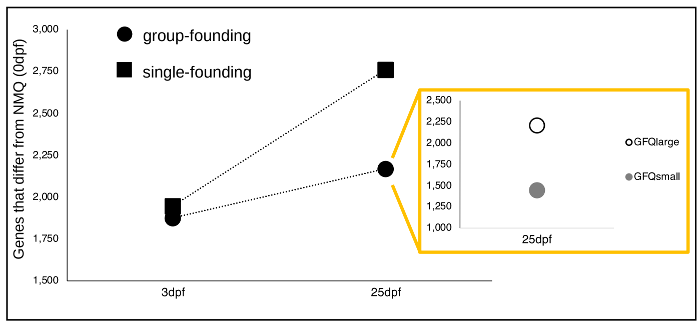
C



A

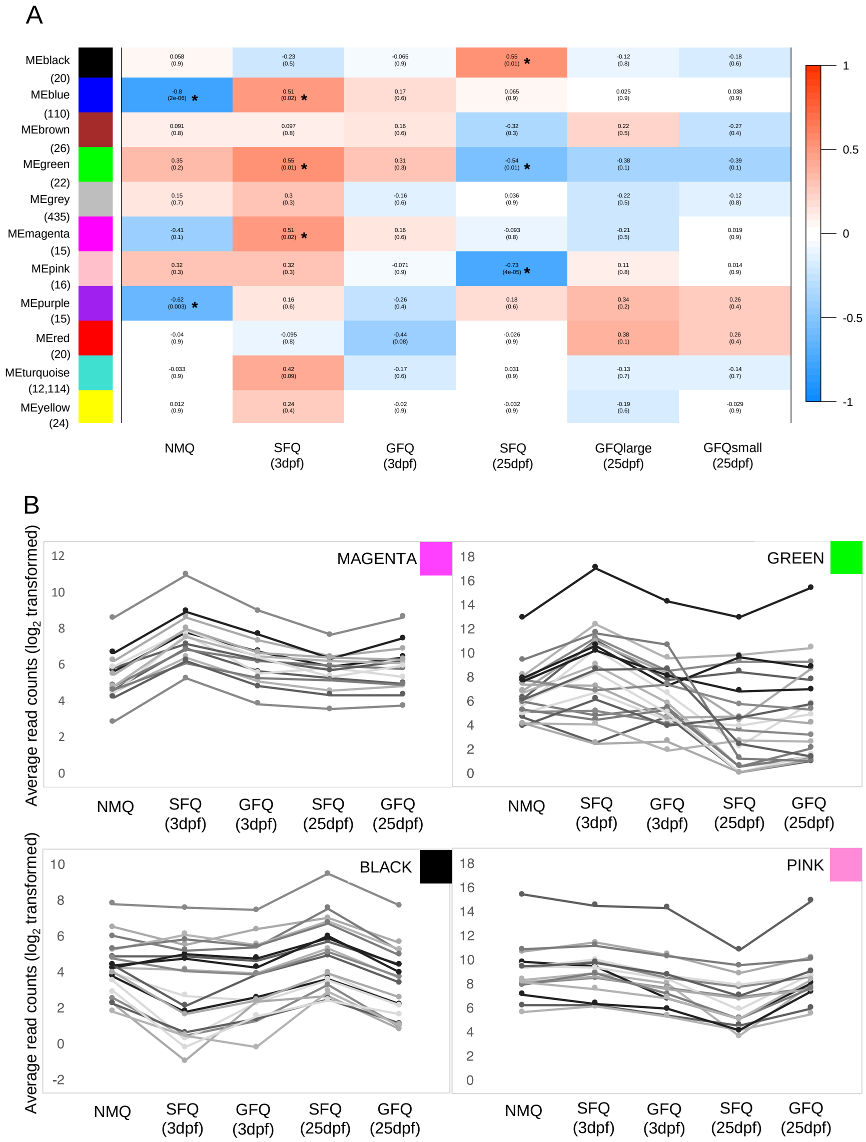


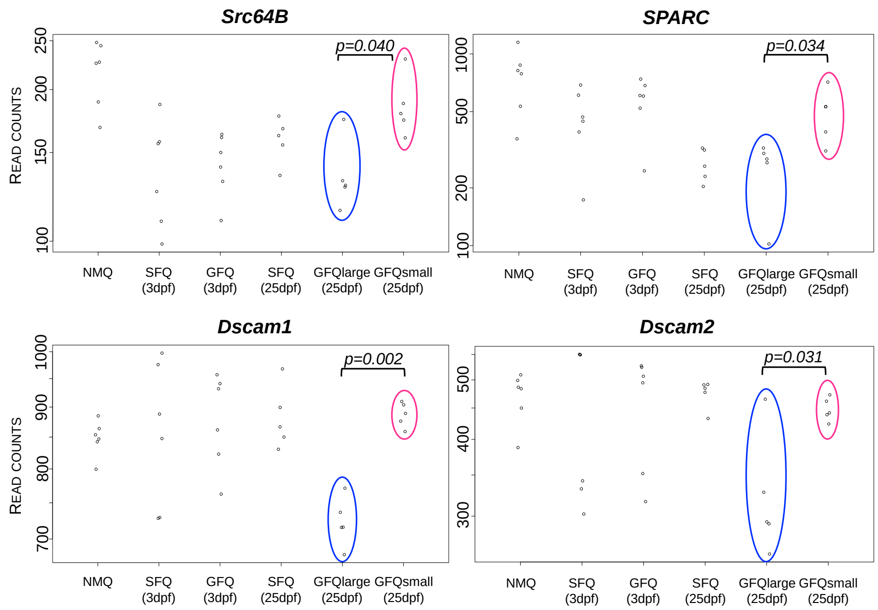
B



C

		DEG	>|2-fold|	UP	GENE ONTOLOGY / *KEGG PATHWAYS / *GENE NAMES*
3dpf	**GFQ vs. NMQ**	1,874	90 (5%)	961 (51%)	lipid metabolic process (81), single-organism process (655), transmembrane transport (77), ion homeostasis (1)
	SFQ vs. NMQ	1,948	94 (5%)	990 (51%)	metabolic pathways (139), organic acid metabolic process (73), transmembrane transport (76), lipid metabolic process (79), single-organism process (667), cytoplasmic translation (31), *citrate cycle (13)
	GFQ vs. SFQ	1	0	0	*Slit homolog 1 protein*
25dpf	**GFQ vs. NMQ** **large** **small**	2,169 2,208 1,449	107 (5%) 90 (4%) 86 (6%)	1,036 (48%) 1,003 (45%) 694 (48%)	single-organism process (754), *metabolic pathways (168), transmembrane transport (86), lipid metabolic process (84), ion transport (79), carboxylic acid metabolic process (67), purine nucleotide metabolic process (60), *ribosome (51), small molecule biosynthetic process (35), microtubule organizing center organization (34), anion transport (27), gluconeogenesis (16), regulation of pH (13), *metabolism of xenobiotics by cytochrome P450 (7)
	SFQ vs. NMQ	2,763	136 (5%)	1,254 (45%)	cellular process (914), transport (278), carboxylic acid metabolic process (82), microtubule cytoskeleton organization (80), *ribosome (66), ribosome biogenesis (66), *oxidative phosphorylation (62), centrosome organization (50), small molecule biosynthetic process (43), *carbon metabolism (40), anion transport (30), hydrogen transport (23), ATP biosynthetic process (15), carbohydrate catabolic process (15), isoprenoid biosynthetic process (11), glycolytic process (10)
	GFQ vs. SFQ	659	17 (3%)	482 (73%)	oxidation-reduction process (46), fatty acid metabolic process (16), translation (46), centrosome duplication (14)
	GFQlarge vs. GFQsmall	5	0	3	*Translocase of the inner mitochondrial membrane 17b, two ribosomal proteins (RpL9 and RpS30) and two uncharacterized genes*


A
MEblack (20)
MEblue (110)
MEbrown (26)
MEgreen (22)
MEgrey (435)
MEmagenta (15)
MEpink (16)
MEpurple (15)
MEred (20)
MEturquoise (12,114)
MEyellow (24)
NMQ
SFQ (3dpf)
GFQ (3dpf)
SFQ (25dpf)
GFQlarge (25dpf)
GFQsmall (25dpf)
1
0.5
0
-0.5
-1
B
Average read counts (log2 transformed)
MAGENTA
GREEN
BLACK
PINK
NMQ
SFQ (3dpf)
GFQ (3dpf)
SFQ (25dpf)
GFQ (25dpf)


Src64B
p=0.040
READ COUNTS
100
150
200
250
SPARC
p=0.034
100
200
500
1000
Dscam1
p=0.002
700
800
900
1000
Dscam2
p=0.031
300
400
500
NMQ
SFQ (3dpf)
GFQ (3dpf)
SFQ (25dpf)
GFQlarge (25dpf)
GFQsmall (25dpf)