

Progress on Work Package 1C

12 May 2021

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- ▶ Use individual-based modelling (i.e., agent-based modelling) to simulate genetic architecture and landscapes
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- ▶ Parameterise with data from *Helicoverpa armigera* and data from Work Package 1A

Simulate genetic architecture

##	rG	Diff	Diff2	TRT1	TRT2
## 1	0.47205394	Isolate	Control-Infected	SC	SB
## 2	0.54752141	Isolate	Control-Infected	SC	SM
## 3	0.31357864	Crop	Uninfected	SC	MC
## 4	-0.33459966	Both	Control-Infected	SC	MB
## 5	0.06347942	Both	Control-Infected	SC	MM
## 6	-0.38837056	Crop	Uninfected	SC	TC
## 7	0.06358750	Both	Control-Infected	SC	TB
## 8	-0.09823783	Both	Control-Infected	SC	TM
## 9	0.53766718	Isolate	Isolate Genus	SB	SM
## 10	0.17474769	Both	Control-Infected	SB	MC
## 11	0.26738775	Crop	Infected	SB	MB
## 12	-0.10436088	Both	Isolate Genus	SB	MM
## 13	-0.09942243	Both	Control-Infected	SB	TC
## 14	-0.14326498	Crop	Infected	SB	TB
## 15	-0.42090644	Both	Isolate Genus	SB	TM
## 16	-0.05742982	Both	Control-Infected	SM	MC

Simulate genetic architecture

Correlation matrix derived from Work Package 1A

##		SC	SB	SM	MC	MB	MM	TC	TB	TM
##	SC	1.000	0.472	0.548	0.314	-0.335	0.063	-0.388	0.064	-0.098
##	SB	0.472	1.000	0.538	0.175	0.267	-0.104	-0.099	-0.143	-0.421
##	SM	0.548	0.538	1.000	-0.057	0.137	-0.305	-0.372	-0.010	0.023
##	MC	0.314	0.175	-0.057	1.000	0.551	0.337	-0.268	-0.033	0.021
##	MB	-0.335	0.267	0.137	0.551	1.000	0.518	0.020	-0.275	0.038
##	MM	0.063	-0.104	-0.305	0.337	0.518	1.000	0.010	-0.260	-0.156
##	TC	-0.388	-0.099	-0.372	-0.268	0.020	0.010	1.000	0.250	0.388
##	TB	0.064	-0.143	-0.010	-0.033	-0.275	-0.260	0.250	1.000	0.597
##	TM	-0.098	-0.421	0.023	0.021	0.038	-0.156	0.388	0.597	1.000

Need to create a quantitative genetic architecture that produces these trait correlations from allele values

Traits

1

2

3

4

5

6

7

8

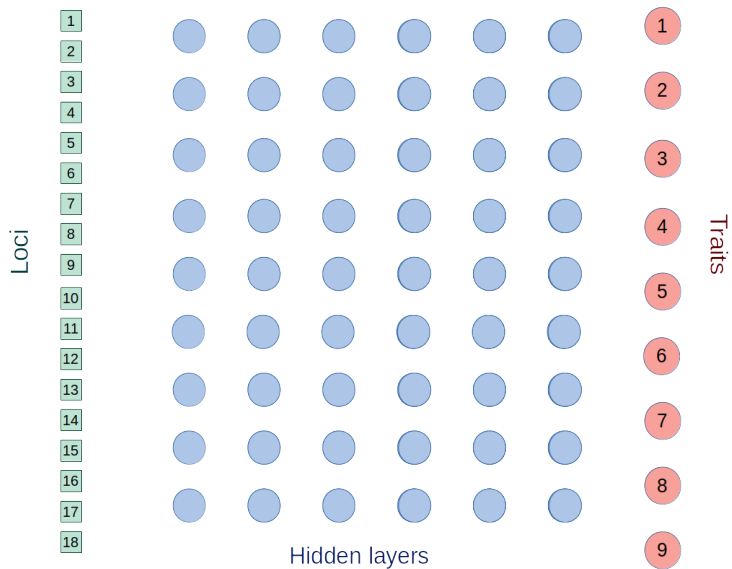
9

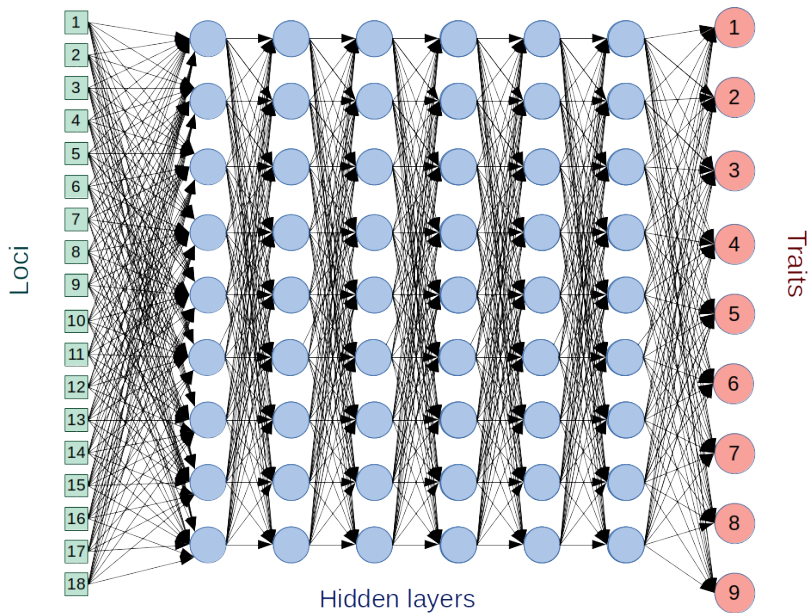
Loci

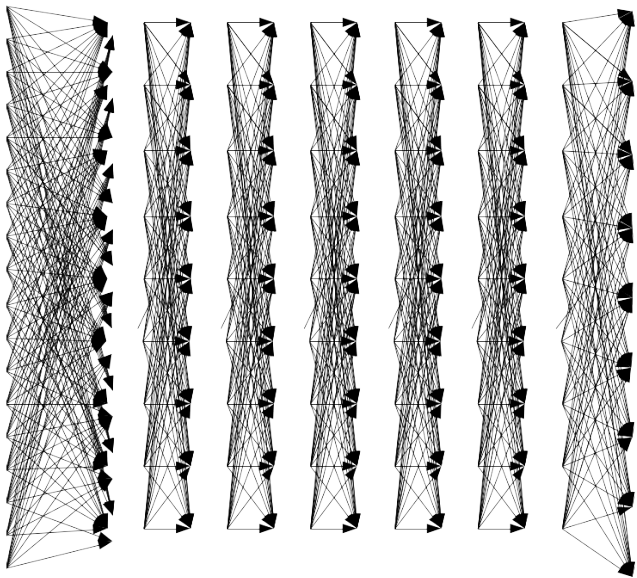
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18

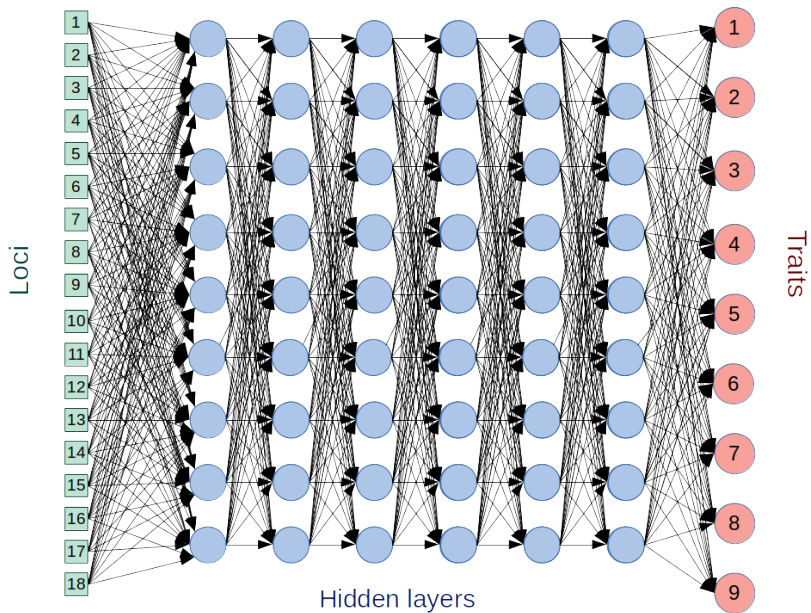
Traits

- 1
- 2
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Getting from loci to traits

Use an evolutionary algorithm to find arrow values

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7. N offspring networks replace parents
8. Repeat 2-7 until termination criteria satisfied

End result is a set of network values that gets close the empirical matrix when loci have standard random normal values

The helicoverpa package

An R function `mine_gmatrix` can find network values given:

- ▶ A square empirical matrix
- ▶ Arbitrary loci number
- ▶ Arbitrary number of hidden layers
- ▶ Various algorithm input options

```
eg_net <- mine_gmatrix(gmatrix = gmt, loci = 18,  
                        layers = 6, mu_rate = 0.1,  
                        mu_sd = 0.04, net_N = 8000,  
                        test_N = 1000);
```

The helicoverpa package

```
=====
Initialising gmatrix mining...
=====
```

Gen: 0	Stress: -1.300040	Min: -1.300051
Gen: 1	Stress: -1.300052	Min: -1.300150
Gen: 2	Stress: -1.300119	Min: -1.300985
Gen: 3	Stress: -1.300434	Min: -1.303620
Gen: 4	Stress: -1.301580	Min: -1.311596
Gen: 5	Stress: -1.305397	Min: -1.332303
Gen: 6	Stress: -1.316018	Min: -1.388752
Gen: 7	Stress: -1.342745	Min: -1.537480
Gen: 8	Stress: -1.400662	Min: -1.643793
Gen: 9	Stress: -1.483798	Min: -1.720355
Gen: 10	Stress: -1.552275	Min: -1.832071
Gen: 11	Stress: -1.580273	Min: -1.863808

Building the empirical matrix from random normal loci

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9]
## [1,] 1.000 0.610 0.809 0.334 -0.214 -0.303 -0.746 -0.220 -0.399
## [2,] 0.610 1.000 0.707 0.391 0.347 -0.146 -0.550 -0.713 -0.768
## [3,] 0.809 0.707 1.000 0.122 -0.037 -0.449 -0.739 -0.275 -0.361
## [4,] 0.334 0.391 0.122 1.000 0.646 0.447 -0.647 -0.499 -0.470
## [5,] -0.214 0.347 -0.037 0.646 1.000 0.681 -0.364 -0.713 -0.583
## [6,] -0.303 -0.146 -0.449 0.447 0.681 1.000 -0.131 -0.475 -0.468
## [7,] -0.746 -0.550 -0.739 -0.647 -0.364 -0.131 1.000 0.411 0.528
## [8,] -0.220 -0.713 -0.275 -0.499 -0.713 -0.475 0.411 1.000 0.891
## [9,] -0.399 -0.768 -0.361 -0.470 -0.583 -0.468 0.528 0.891 1.000
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Next steps

- ▶ Further improve the evolutionary algorithm
- ▶ Model *Helicoverpa* with random initial alleles
- ▶ Simulate *Helicoverpa* on a landscape
- ▶ Observe evolution given changing pesticide and crop scenarios
- ▶ Complete R package and publications