Supporting Information

ARE WE UNDERESTIMATING THE GENETIC VARIANCES OF DIMORPHIC TRAITS?

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S1 Univariate and bivariate animal models

Univariate model

A univariate animal model of a trait expressed in two morphs within the population can be specified as:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}_{\mathbf{a}}\mathbf{a} + \mathbf{e} \qquad \text{(S1.1)}$$

When every individual has only one measurement, $\mathbf{y}$ is a nx1 vector of phenotypes in a population of n individuals and $\mathbf{X}$ is a nxf design matrix (i.e., contains 0s and 1s), where f is the number of levels of fixed effects in the model, and contains 1s in rows occupied by observations with a particular level of the fixed effect in the fth column. The matrix $\mathbf{X}$ relates the observation in $\mathbf{y}$ to the appropriate fixed effect (mean) in $\boldsymbol{\beta}$. If morph is included as a fixed effect to account for differences in mean phenotype, then $\mathbf{X}$ contains 1s in the first column at rows occupied by morph M1 (corresponding to rows in $\mathbf{y}$) and 1s in the second column at rows occupied by morph M2. The matrix $\mathbf{Z}_{\mathbf{a}}$ is an nxn design matrix which associates the phenotypic observation in $\mathbf{y}$ to the breeding value in $\mathbf{a}$. The variables $\mathbf{a}$ and $\mathbf{e}$ are the nx1 vectors of additive genetic effects and environmental effects, respectively. The random variables $\mathbf{a}$

and **e** are assumed normally distributed with means of zero and variances of $Var(\mathbf{a})=\mathbf{G_a}\otimes\mathbf{A}$, where **A** is the additive genetic relationship matrix ($\otimes$ symbolizes the direct product between two matrices), and $Var(\mathbf{e})=\mathbf{R}\otimes\mathbf{I}$, where **I** is an identity matrix (*n*x*n*, with 1s along the diagonal). In this model, $\mathbf{G_a}=\sigma^2_{\mathbf{a}}$ where $\sigma^2_{\mathbf{a}}$ is the additive genetic variance in the base population and $\mathbf{R}=\sigma^2_{\mathbf{e}}$, the environmental variance.

Bivariate model

A bivariate model of a trait expressed in two morphs within the population can be specified as:

$$\begin{bmatrix}\mathbf{y}_1\\ \mathbf{y}_2\end{bmatrix}=\begin{bmatrix}\mathbf{X}_1 & \mathbf{0}\\ \mathbf{0} & \mathbf{X}_2\end{bmatrix}\begin{bmatrix}\beta_1\\ \beta_2\end{bmatrix}+\begin{bmatrix}\mathbf{Z}_{\mathbf{a}1} & \mathbf{0}\\ \mathbf{0} & \mathbf{Z}_{\mathbf{a}2}\end{bmatrix}\begin{bmatrix}\mathbf{a}_1\\ \mathbf{a}_2\end{bmatrix}+\begin{bmatrix}\mathbf{e}_1\\ \mathbf{e}_2\end{bmatrix} \qquad \text{(S1.2)}$$

In equation S1.2, **a** (the bivariate distribution of $\mathbf{a}_1$ and $\mathbf{a}_2$) and **e** (the bivariate distribution of $\mathbf{e}_1$ and $\mathbf{e}_2$) are assumed to represent random effects described by multivariate normal distributions. The $Var(\mathbf{a})=\mathbf{G_a}\otimes\mathbf{A}$, where $\mathbf{G_a}$ is a 2x2 matrix (see equation 3 in main text).

S2 Literature search

To evaluate the extent to which morph-specific estimates of additive genetic variances are estimated in the literature, we sampled four journals that present the majority of estimates of additive genetic variances in evolutionary ecology: *Evolution*, *the American Naturalist*, *Journal of Evolutionary Biology*, and *Heredity*. For each journal we included the issues for January through December 2013 and January through October 2014 (22 months). We read the title, abstract, and keywords of every paper published in this sample to determine if genetic variances or heritabilities were estimated. If yes, we read the full paper and categorized it according to: (1) the type of trait studied (monomorphic, dimorphic, or polymorphic), (2) whether morph was included in the statistical analysis, (3) whether morph was included as a fixed effect, (4) whether a bivariate model of both morphs (or multivariate in the case of a polymorphism) was used to estimate morph-specific genetic variances, and (5) whether morphs were analyzed in separate statistical models (regardless of how the study was categorized in 4).

We considered morph was included as a fixed effect (3) if it was either entered directly in the statistical model as a fixed effect or if the raw phenotypic data were mean centered across morphs before analyses (effectively the same as including fixed effect in the model). Similarly, we considered the morph to be modeled using a bivariate model (4) if the morphs were entered as separate traits or if a random interaction with morph was included (e.g., morph-by-sire family in a sire variance component model or morph-by-identity in an animal model). Finally, we did not include papers that either estimated additive genetic variances and heritabilities from simulated data or estimated mutational genetic variances.

Table S2.1 Results from the literature sample

Ref.	Organism	Trait(s)	1-Morph	2-Morph in analysis	3-Fixed effect	4-Bivariate model	5-Separate morph models
1	Hyla versicolor	advertisement call	Dimorphic	yes	yes	no	no
2	Agalychnis callidryas	risk-induced hatching timing & morphology	Dimorphic	yes	yes	yes	no
3	Tyto alba	color spots	Dimorphic	yes	yes	no	no
4	Tyto alba	nestling vocalizations	Dimorphic	yes	yes	no	no
5	Hirundo rustica	flight initiation distance	Polymorhpic	no	no	no	no
6	Cyanistes caeruleus	egg characteristics	Polymorphic	yes	yes	yes	no
7	Cyanistes caeruleus	body mass	Polymorphic	yes	yes	yes	no
8	Ficedula albicolis	tail, tarsus, wing, & mass	Dimorphic	yes	yes	no	no
9	Ficedula albicollis and Taeniopygia guttata	morphology & sexually selected traits	Dimorphic	yes	yes	no	no
10	Falco tinnunculus	coloration, body mass, & immunity	Dimorphic & Polymorphic	yes	yes	no	no (age) yes (sex)
11	Acrocephalus arundinaceus	wing tarsus length	Dimorphic	yes	yes	yes	yes
12	Parus major	oxidative damage & resistance to oxidative stress	Dimorphic	yes	yes	yes	yes
13	Parus major	clutch size	Monomorphic	NA	NA	NA	NA
14	Parus major	gonad size	Polymorphic	yes	yes	yes	yes
15	Parus major	egg-laying dates (female)	Dimorphic	yes	yes	yes	no
16	Parus major and Taeniopygia guttata	plumage & beak color	Dimorphic	yes	yes	no	no
17	Anser anser	dominance rank & aggression	Dimorphic	yes	yes	yes	yes
18	Perisoreus infaustus	body mass	Dimorphic	yes	yes	no	no
19	Melospiza melodia	female extra-pair reproduction and male paternity success	Monomorphic	NA	NA	NA	NA
20	Melospiza melodia	male reproductive success	Monomorphic	NA	NA	NA	NA
21	Larus michahellis	antioxidant defence, endocrine signal, & body mass	Dimorphic	yes	yes	yes	yes
22	Taeniopygia guttata	neural traits associated with song	Dimorphic	yes	yes (resources) no (sex)	yes (resources) no (sex)	no
23	Taeniopygia guttata	morphology, male sexual activity & basal metabolic rate	Dimorphic & Polymorphic	yes	yes	yes	no
24	Hippopodina iririkiensis	fitness	Polymorphic	yes	yes	yes	yes
25	Heliocidaris erythrogramma armigera	fertilization & hatching success	Dimorphic	yes	yes	yes	no

26	Gasterosteus aculeatus	survival & body size	Polymorphic	yes	yes	yes	no
27	Salmo salar	fitness	Dimorphic	yes	yes	no	yes
28	Salmo salar	morphology	Dimorphic	yes	yes	yes	no
29	Gasterosteus aculeatus	body size & shape	Dimorphic & Polymorphic	yes	yes	yes (environment) no (sex)	no
30	Lasius niger	cuticular hydrocarbons, fertility, & head size	Dimorphic	yes	no	no	yes
31	Gryllodes sigilatus	oxidative damage, antioxidant protection, reproductive effort, lifespan, & ageing	Dimorphic	yes	?	yes	no
32	Gryllodes sigillatus	female spermatophylax feeding behavior & amino acid composition	Monomorphic	NA	NA	NA	NA
33	Teleogryllus commodus	mate choice	Dimorphic	yes	yes	yes	no
34	Gnatocerus cornutus	mandable size & locomotor activity	Dimorphic	yes	no	no	yes
35	Sepsis punctum	development rate	Dimorphic & Polymorphic	yes	yes	yes	no
36	Drosophila melanogaster	macronutrient preferences	Dimorphic	yes	?	yes	no
37	Drosophila simulans	cuticular hydrocarbons	Dimorphic	yes	yes	no	yes
38	Drosophila yakuba and santomea	pigmentation	Dimorphic	yes	yes	no	yes
39	Drosophila melanogaster	egg-to-adult viability	Dimorphic	yes	yes	yes	no
40	Drosophila melanogaster	lifespan	Dimorphic	yes	yes	yes	no
41	Drosophila melanogaster	cuticular hydrocarbons	Dimorphic	yes	yes	yes	no
42	Drosophila serrata	mating preferences	Dimorphic	yes	yes	yes	no
43	Drosophila simulans	cuticular hydrocarbons	Dimorphic	yes	yes	yes	yes
44	Drosophila serrata	fitness	Dimorphic & Polymorphic	yes	yes	yes	yes
45	Drosophila serrata	contact pheromones	Dimorphic & Polymorphic	yes	yes	yes	no
46	Drosophila melanogaster	fecundity & copula duration	Monomorphic	NA	NA	NA	NA
47	Drosophila serrata	cuticular hydrocarbons	Monomorphic	NA	NA	NA	NA
48	Drosophila simulans	heat tolerance	Monomorphic	NA	NA	NA	NA
49	Drosophila serrata	cuticular hydrocarbons	Polymorphic	yes	yes	no	yes
50	Drosophila simulans	cuticular hydrocarbons	Polymorphic	yes	yes	yes	no
51	Melitaea cinxia	metabolic rates	Dimorphic	yes	yes	no	yes
52	Tenebrio molitor	immune response, melanisation, & morphology	Dimorphic & Polymorphic	yes	?	yes	no

53	Tribolium castaneum	external immune defences	Monomorphic	NA	NA	NA	NA
54	Tribolium castaneum	growth & life history	Polymorphic	yes	yes	yes	no
55	Gryllus firmus	melanization, ovary/testis mass & DLM mass	Dimorphic & Polymorphic	yes	yes	yes	yes
56	Callosobruchus maculatus	fitness	Dimorphic	yes	no	yes	no
57	Nauphoeta cinerea	discontinuous gas exchange, metabolic rate, & body mass	Dimorphic	yes	yes	no	yes
58	Enchenopa binotata	female mate preference	Monomorphic	NA	NA	NA	NA
59	Enchenopa binotata	mate preferences	Monomorphic	NA	NA	NA	NA
60	Bemisia tabaci	survival & fecundity	Dimorphic	yes	yes	no	yes
61	Bos taurus	social dominance	Monomorphic	NA	NA	NA	NA
62	Homo sapiens	ages at first & last reproduction	Dimorphic	yes	?	yes	yes
63	Homo sapiens	metabolic profiles	Monomorphic	NA	NA	NA	NA
64	laboratory house mice	wheel running behavior	Dimorphic	yes	yes	yes	yes
65	Suricata suricatta	growth & size	Dimorphic	yes	yes	yes	yes
66	Ovis aries	antibody titer & body weight	Polymorphic	yes	yes	yes	no
67	Saimiri boliviensis	neonate mass	Dimorphic	yes	yes	yes	no
68	Ipomoea purpurea	fitness & tolerance to competition	Dimorphic	yes	yes	yes	no
69	Plantago coronopus	reproductive & vegetative traits	Dimorphic & Polymorphic	yes	yes	yes	no
70	Solanum carolinense	resistance to herbivory	Monomorphic	NA	NA	NA	NA
71	Pinus pinaster	early seedling performance	Dimorphic	yes	yes	yes	no
72	Ipomoea hederacea	size, flowering time, & seed number	Monomorphic	NA	NA	NA	NA
73	Arabidopsis lyrata	seed size	Monomorphic	NA	NA	NA	NA
74	Geranium carolinianum	competitive ability	Polymorphic	yes	no	yes	no
75	Arabidopsis lyrata	plant performance & coping with drought	Polymorphic	yes	yes	no	yes
76	Arabidopsis thaliana	13 varied traits	Polymorphic	yes	yes	yes	yes
77	Pinus radiata	resistance to herbivores	Dimorphic	yes	yes	yes	no
78	Eucalyptus globulus	disease resistance	Polymorphic	yes	yes	yes	no
79	Schistocephalus solidus	fitness	Monomorphic	NA	NA	NA	NA

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