Adaptive Phenotypic Plasticity for Lif- History and Less Fitness-Related Traits

Cristina Acasuso-Rivero[1,2], Courtney J. Murren[3], Carl D. Schlichting[4], Ulrich K. Steiner[1,5]

[1]INSERM U1001, Université Paris Descartes, Sorbonne Paris Cité, Faculté Cochin, 75014 Paris, France
[2]Current address: Department of Veterinary Medicine, University of Cambridge;
[3]Department of Biology, College of Charleston, Charleston SC 29424
[4]Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269
[5]Department of Biology, Center of Population Dynamics, University of Southern Denmark, 5230 Odense, Denmark

DOI: 10.1098/rspb.2019.0653

SUPPLEMENTARY MATERIALS

Supplementary Material 1: CATEGORIES

A) REPORTED CATEGORIES

From all the reported species, 173 were animals: 74 vertebrates, mostly amphibians (51 spp.), 12 reptiles, 11 bony fishes, 2 mammals. The data includes 77 species of arthropods, mainly insects (62 spp.) and crustaceans (13 spp.) There are only a short number of studies performed on plasticity due to interaction between members of the same species (intraspecific), photoperiods (5% each) or intrinsic resources (0.1%).

We merged the phyla *Annelida*, Arthropoda, Bryozoa, Ciliophora, Cnidaria, Echinodermata, Mollusca and Nematoda into *Invertebrates* and named the classification *Taxa* which consisted of *Chordates*, *Invertebrates*, *Flowering Plants* and *Green Algae*. We constructed a hierarchical model including: species/genus/class/phylum/Taxa as fix effects. We then compared the models discarding the lowest classification each step and found no difference in the AIC between models. Thus, the CV_E of eukaryotes will differ between high taxa, regardless of the lower taxonomic orders.

Table S1: Information collected from each study.

Variable	Description or categorisation
Reference	Code
Year of publication	1987-2011
Species	Genus and species reported by authors.
Phylum (Classes)	According to NCBI taxonomy [44]: 1) Annelida [*Polychaeta*]. 2) Arthropoda [*Arachnida, Collembola, Crustacea, Insecta*]. 3) Bryozoa [*Gymnolaemata*]. 4) Chlorophyta [*Chlorophyta*]. 5) Chordata [*Actinopterygii, Amphibia, Mammalia, Sauropsida*]. 6) Ciliophora [*Spirotrichea*]. 7) Cnidaria [*Anthozoa*]. 8) Echinodermata [*Ophiurida*]. 9) Magnoliophyta [*Eudicotyledons, Liliopsida, Magnoliids*]. 10) Mollusca [*Gastropoda*]. 11) Nematoda [*Chromadorea*].
Population	Subspecies or distinct populations of one same species reported in one study.
Number of **envi**ronments	Number of the differential environments into which a single genotype was subjected.
Environment type	1) Environment Quality. 2) Interspecific Interactions. 3) Intraspecific Interactions 4) Intrinsic Resources. 5) Photoperiods and Light 6) Temperature.
Location of the experiment	1) Field. 2) Pseudo-controlled. 3) Controlled conditions. 4) Both (controlled and field).
Breeding	Breeding conditions: 1) Wild. 2) Controlled. 3) Both.
Trait type	We classified trait types into 6 categories and 46 sub-categories [see Supplementary material 1 for sub-categories]: Non-fitness traits: 1) Behavioural. 2) Morphological. 3) Metabolism & Physiology. 4) Developmental. Fitness traits: 1) Reproductive. 2) Survivorship.
Sample size (**N**)	Number of independent units.
Kind of traits for an individual study	If the authors reported within a single paper: 1: Only fitness traits. 2: Only non-fitness traits. 3: Both.
Repetitions	Number of times that the same species [at different times or distinctive populations] was subjected to the same differential environments and recorded the same trait. Each report within a single study was collected separately and weighted for the number of repetitions.

Table S2: Summary of the sample sizes (N) from the data set analysed.

Taxa	Environment type	Location	Breeding	Trait type	Repetitions	N
Invertebrates 3453	Interspecific interactions 2351	Controlled conditions 4889	Controlled conditions 2768	Morphological 2740	Min. 1	Min. 2
Chordates 2001	Environment quality 1787	Pseudo-captive 561	Wild 1611	Reproductive 1280	Max. 60	Max. 2110
Flowering Plants 364	Temperature 1115	Field 296	Both 1486	Behavioural 640		
Green Algae 67	Intraspecific interactions 321	Both 139	Unknown 20	Developmental 595		
	Photoperiods & light 305			Metabolism & Physiology 385		
	Intrinsic resources 6			Survivorship 245		

B) CATEGORISATION OF TRAIT SUB-TYPES

Behavioural: Activity, Alertness, Attack, Avoidance, Distance to conspecifics, Foraging, Mating, Phototaxis, Self-care, Settling and Speed.
Morphological: Colour, Extended phenotype, Growth rate, Mass, Mass of an organ, Number of organs, Shape, Size and Size of an organ.
Metabolism & Physiology: Chemical, Enzymatic, Immunological, Metabolic activity, Resistance and Resources.
Developmental: Abnormalities, Development rate, Growth rate, Sex ratio, Stages and Time.
Reproductive: Fecundity, Reproductive investment, Mass of reproductive organ, Number of eggs, Number of reproductive organs, Offspring mass, Offspring size, Offspring survival, Offspring volume, Population size or growth, Reproductive time, Size of reproductive organ of offspring, Size of reproductive organ and Volume of reproductive organ.
Survivorship: Survival, Number of surviving adults, juveniles or clutches, Adult Longevity, Life span, Offspring eaten by predators, Age of dead and Cumulative mortality.

C) MAIN SUB-CATEGORIES OF THE ENVIRONMENTS

Environment Quality: Oxygen, food availability, hydration, salinity, flying stress, humidity, depth, toxic substances in the environment, deforestation, water flow, prey size, fertilization.
Photoperiods and Light: Diapause, circadian cycles, day light duration, light availability and photo-phases.
Temperature: Chilling /no chilling and temperature gradients.
Intraspecific Interactions: Density, conspecifics presence (e.g. raised with only females) and mating.
Interspecific Interactions: Predators and predator cues, symbionts, parasites and parasitoids.
Intrinsic Resources: Autonomy.

Supplementary Material 2: ASSESSING PUBLICATION BIAS

Funnel plot illustrating absence of publication bias by the symmetry of the graph and by the association between the size of the effect and the variances [1]. Note, that many of the data points plotted are already means, because they are extracted from studies that reported plasticity and, in such studies genotypes, or treatment groups are only reported as means.

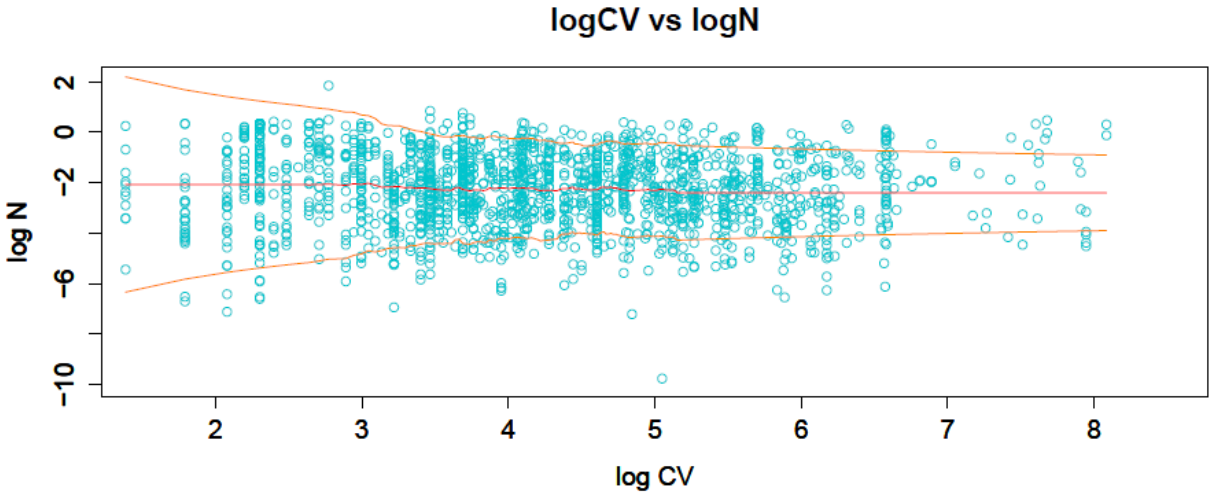

Figure S1: Funnel plot from all published data collected from 1987-2011.

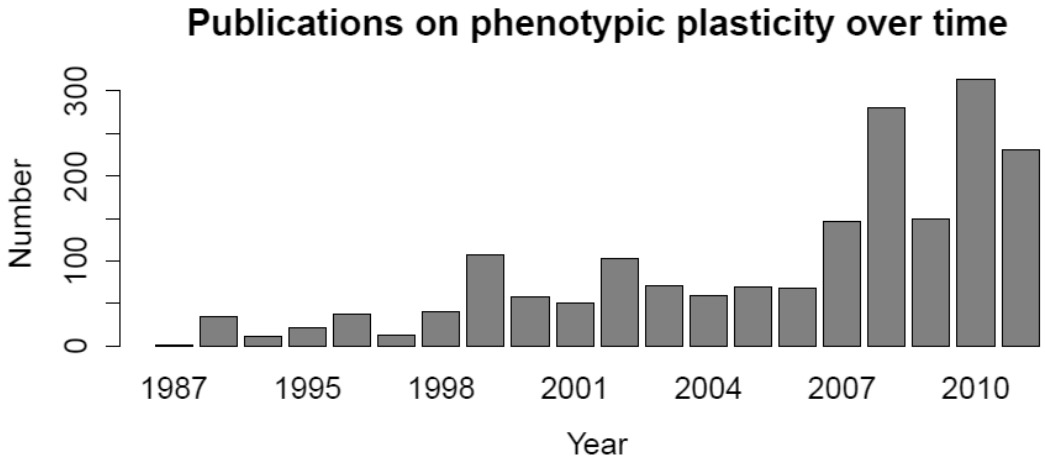

Figure S2: Histogram showing the increase on the publications on phenotypic plasticity over years.

1. Egger M, Smith GD, Schneider M, Minder C. 1997 Bias in meta-analysis detected by a simple, graphical test. *BMJ* **315**, 629–634. (doi:10.1136/bmj.315.7109.629)

Supplementary Material 3: REPRESENTATION OF THE MEAN VALUES OF THE CV FOR TRAIT TYPES, ENVIRONMENTS AND TAXA

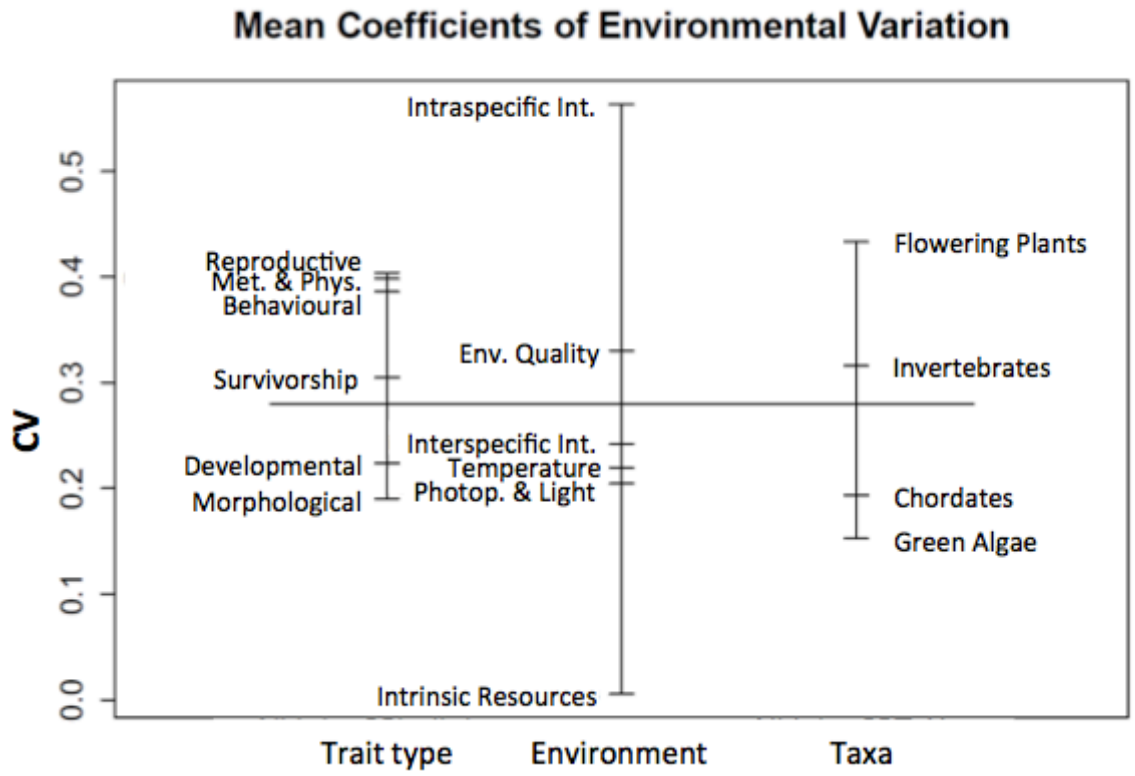

Figure S3: Mean coefficients of variation from trait types, environment types and taxa.

Supplementary Material 4: EVALUATION OF THE MODELS' RESIDUALS

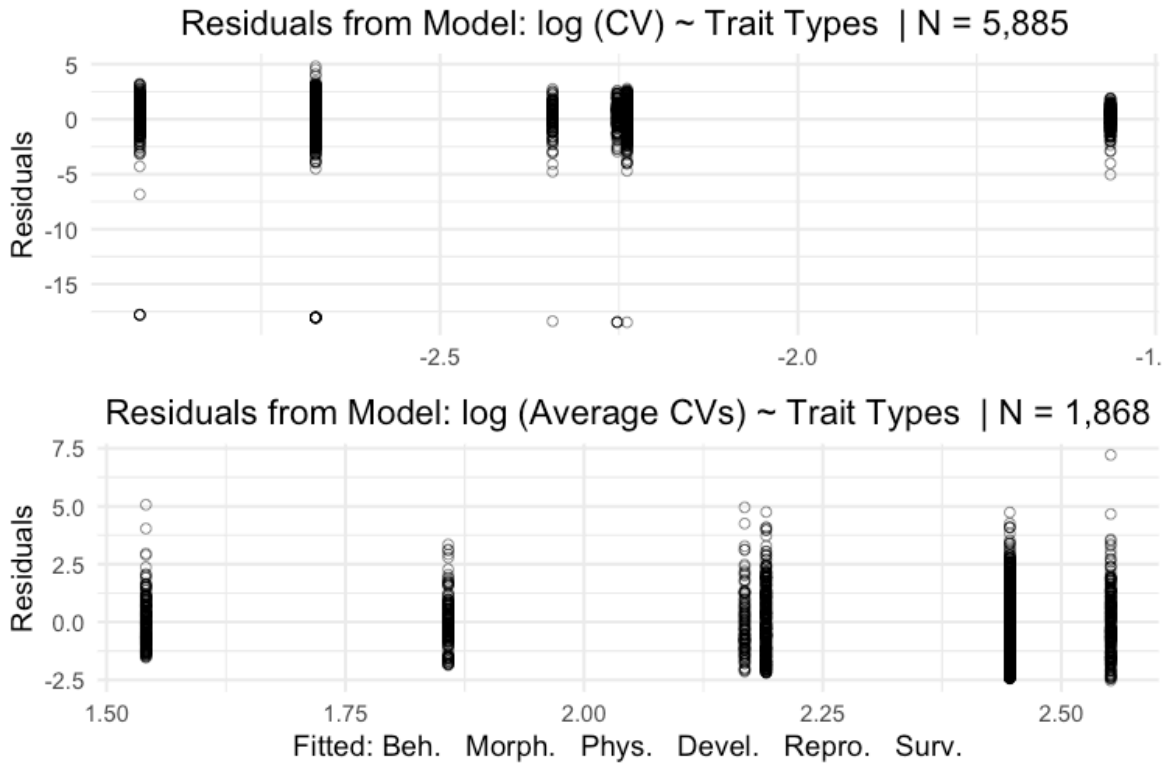

Figure S4: Residuals from the selected models including only the trait types. **Upper panel:** Residuals from the fitted model using the data from the original data set. **Lower panel:** illustrates the residuals from the fitted model using the averages of the CVs.

Supplementary Material 5: WHEN EXCLUDING PLANTS FROM THE ANALYSES TAXA BECOMES LITTLE INFLUENTIAL

Table S3: Competing linear models excluding all plant data and selected based on AIC. Models used as response variable the log transformed Coefficient of Variation (scaled plasticity) and explored combinations of trait type, environment and taxa as fixed effects. Reference study was included as a random effect and repetitions (sample size) as a weighting factor.

No plants	Model	AIC	ΔAIC
Null Model	Intercept only	20534.15	2851.6
1	Trait type	17810.87	128.32
2	Environment	18178.27	495.72
3	Taxa	18205.81	523.26
4	Trait type + Environment	17778.17	95.62
5	Trait type + Taxa	17810.00	127.45
6	Trait type * Environment	17682.23	-0.32
7	Trait type * Taxa	17802.33	119.78
8	Trait type + Environment + Taxa	17777.32	94.77
9	Trait type * Environment + Taxa	17682.55	0

Supplementary Material 6: NO INDICATION OF TRADE-OFFS BETWEEN LIFE-HISTORY TRAITS

Figure S5: Correlation between the CV of reproductive traits and survivorship.

The correlation in Fig. S5 is based on 112 studies that include at least one reproductive trait and one life history trait. Data points represent 254 comparisons between the CV of reproduction and survival within a study. No negative correlation in plasticity between reproduction and survival is observed.