Supplementary Information

Kate Griffin

August 2022

Contents

1 $\boldsymbol{E}$ Estimates **2**

1.1 E Estimates for Active vs Resting Metabolic Rate . . . 2

1.2 E estimates for Juvenile vs Adult individuals . . . 4

2 Residuals vs Fitted values **7**

2.1 $E \sim$ Latitude . . . 7

2.2 $E \sim$ Size . . . 8

2.3 $E \sim$ Latitude $\times$ Size . . . 9

3 Metabolic Rates **10**

4 Data Collection **11**

1 E Estimates

1.1 E Estimates for Active vs Resting Metabolic Rate

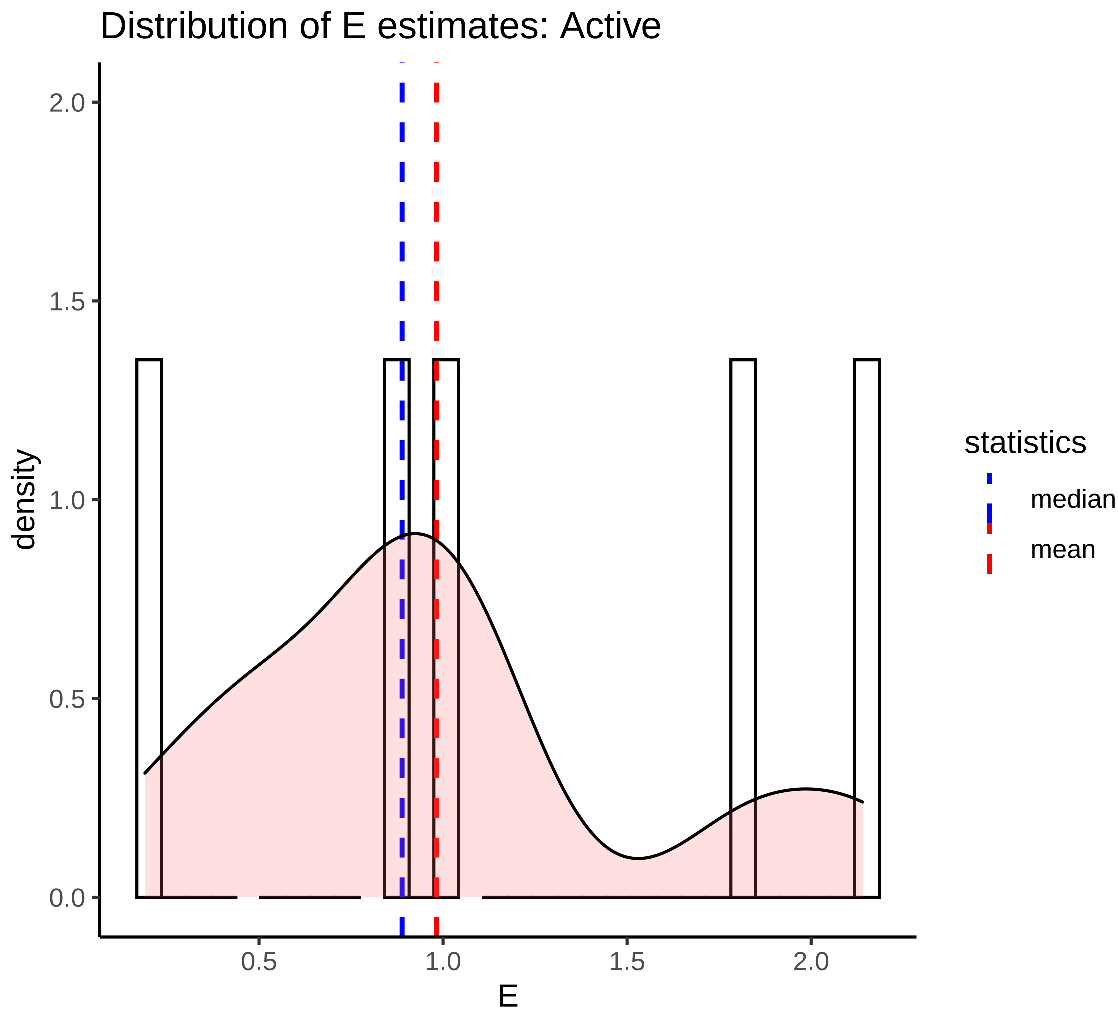

Figure S1: Distribution of E estimates only for observations where metabolic rate was measured as Active Metabolic Rate (AMR). The mean is represented by the broken red line, and the median is represented by the broken blue line. No significant difference was found between AMR and RMR

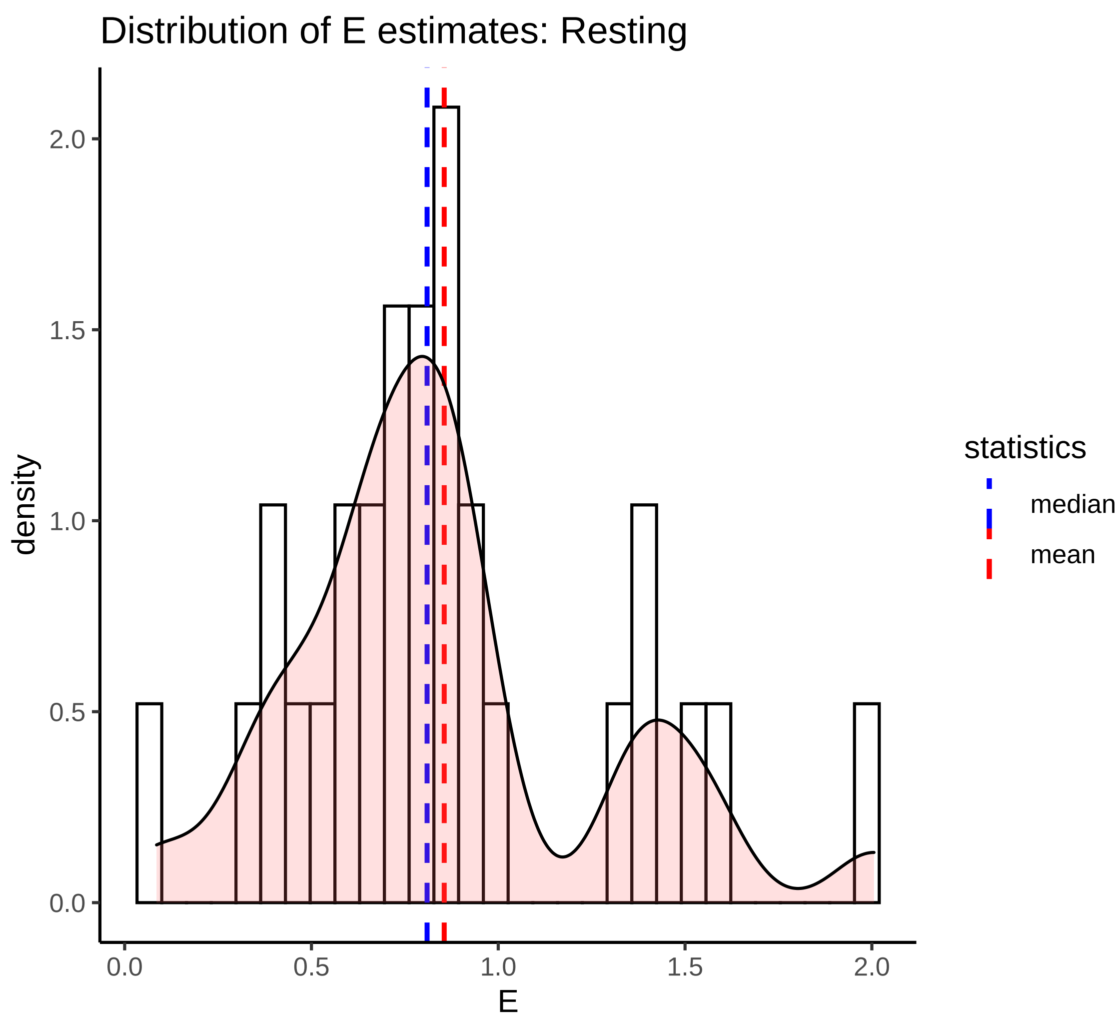

Figure S2: Distribution of E estimates only for observations where metabolic rate was measured as Resting Metabolic Rate (RMR). The mean is represented by the broken red line, and the median is represented by the broken blue line. No significant difference was found between RMR and AMR

1.2 E estimates for Juvenile vs Adult individuals

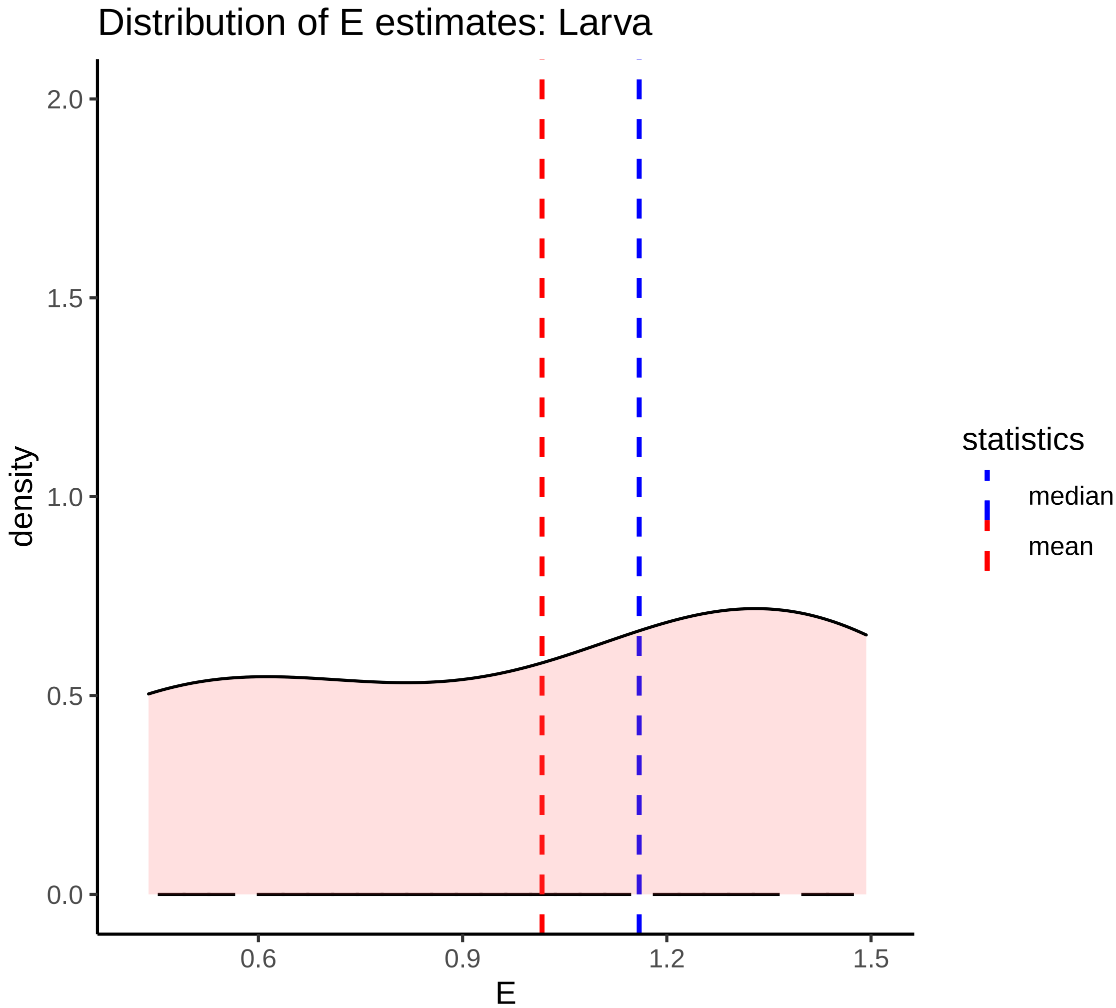

Figure S3: Distribution of E estimates for only juvenile individuals. The mean is represented by the broken red line, and the median is represented by the broken blue line. No significant difference was found between juveniles and adults

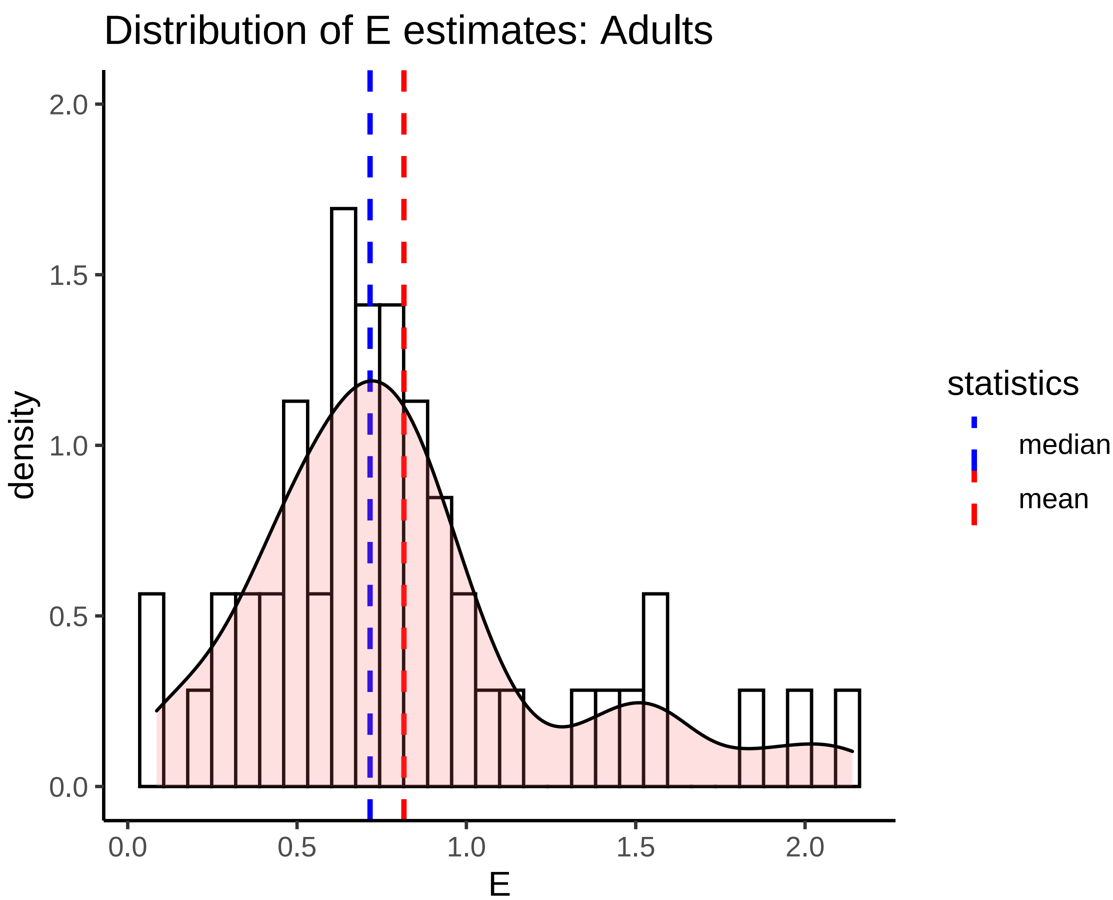

Figure S4: Distribution of E estimates for only adult individuals. The mean is represented by the broken red line, and the median is represented by the broken blue line. No significant difference was found between adults and juveniles

Species	E	E SE	R squared
Bombus vosnesenskii	0.795995691	0.519513655	0.768640021
Paractora dreuxi	0.492948089	0.851216137	0.919069276
Antrops truncipennis	0.519733915	0.12602785	0.949899535
Amara quenseli	0.189969656	26.56378245	0.828858879
Simplocaria metallica	1.018278908	-	0.997071698
Rhynchaenus flagellum	1.090823733	2.156076551	0.675770726
Lycosa carolinensis	0.458168029	0.068119442	0.916614916
Extatosoma tiaratum	0.354621452	-	0.971776666
Apis mellifera carnica	0.994649628	-	0.96923159
Nauphoeta cinerea	1.831636306	0.780667213	0.976736055
Carcinus maenas	2.021669833	0.797398154	0.921334173
Glossina pallidipes	0.612657432	0.165002862	0.893011942
Lithobius curtipes	1.577584106	0.891029051	0.997966087
Lithobius mutabilis	1.40390885	1.245567932	0.998374122
Hippodamia convergens	3.304312841	0.175938531	0.834119522
Encoptolophus sordidus costalis	0.096488088	-	0.986257239
Atta laevigata	0.64706128	0.682273465	0.988949986
Atta sexdens rubropilosa	0.717277783	0.270384912	0.990726469
Melanoplus sanguinipes	0.634944867	1.289783243	0.983196815
Trimerotropis pallidipennis	0.535033066	1.231336204	0.970151636
Scarabaeus gariepinus	0.625501332	1.773276754	0.99823373
Scarabaeus galenus	2.571994622	34.26935686	0.90918744
Scarabaeus rusticus	0.809486625	0.000407649	0.999999978
Scarabaeus westwoodi	0.410396951	0.123821896	0.983942731
Scarabaeus hippocrates	0.930985417	-	0.994743927
Helius waitei	0.713151711	5.217554261	0.911350848
Pterohelaeus spp.	1.337872711	2.459757271	0.88450702
Cerotalis spp.	0.298707389	0.201197941	0.924093513
Carenum spp.	0.638414548	-	0.979833195
Solenopsis invicta	2.139951466	0.356189512	0.907601313
Hydromedion sparsutum	1.581754853	-	0.937387348
Orchelimum fidicinium	0.274484614	-	0.773202971
Pogonomyrmex occidentalis	0.665393192	1.754747013	0.492760921
Glossina morsitans orientalis	0.703865161	0.04459742	0.990186485
Anurogryllus arboreus	1.523104973	3.331325564	0.952372553
Oecanthus celerinictus	0.854619683	0.160350106	0.998971969
Oecanthus quadripunctatus	0.53509874	0.306775497	0.996759376
Pogonomyrmex maricopa	1.108836087	-	0.981722437
Aphaenogaster cockerelli	1.250221318	-	1
Camponotus vafer	1.171060813	-	1
Hophlosphyrum griseus	0.856565787	4.691078676	0.560136089
Pleocoma australis	0.924353735	3.745589741	0.817055749
Bootettix punctatus	0.811671409	-	1
Pachydiplax longipennis	0.684961168	0.723955555	0.991176653
Trimrrotropis suffusa	2.005767452	0.533240686	0.924639446
Cystosoma saundersii	0.852432901	-	1
Camponotus fulvopilosus	0.474979676	0.095955566	0.912478335
Canonopsis sericeus	0.611634659	-	0.99983965
Palirhoeus eatoni	0.085343175	-	0.985598162
Bothrometopus randi	0.877997456	-	0.99790676
Ectemnorhinus marioni	0.713782039	-	1
Ectemnorhinus similis	0.567205605	-	0.999998433
Formica pratensis	0.796054362	0.811442609	0.988767856
Neophilaenus lineatus	0.775596808	-	1
Diceroprocta apache	0.921143865	0.787115087	0.997090503
Xenopsylla ramesis	0.38907	0.237067565	0.826486082
Pogonomyrmex rugosus	0.487265603	0.076805881	0.817923862
Messor capitatus	0.888714102	1.509267874	0.910655578
Cydia pomonella	1.492993509	12.76560293	0.981465908
Limnephilus rhombicus	0.438572259	0.050783072	0.952581951
Glossina morsitans centralis	1.394348932	-	0.998847755
Glossina morsitans morsitans	1.159390825	8.377314878	0.730596403
Alphitobius diaperinus	0.598233005	2.467036709	0.958259648

Table S1: E values calculated for each individual species. Values were estimated by fitting a four-parameter adaptation of the Sharpe-Schoolfield model (Kontopoulos et al., 2020) to each subset of data. Values for R^2 and standard error (SE) for E are also provided

2 Residuals vs Fitted values

2.1 $E \sim$ Latitude

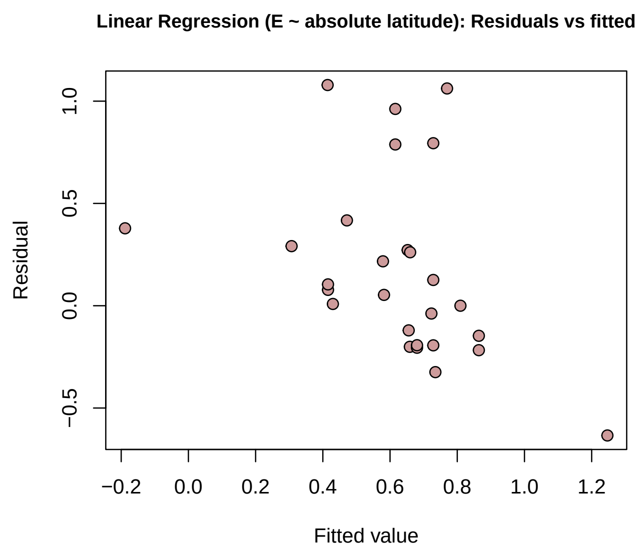

Figure S5: Residual vs fitted value for $E \sim |\text{latitude}|$ linear model

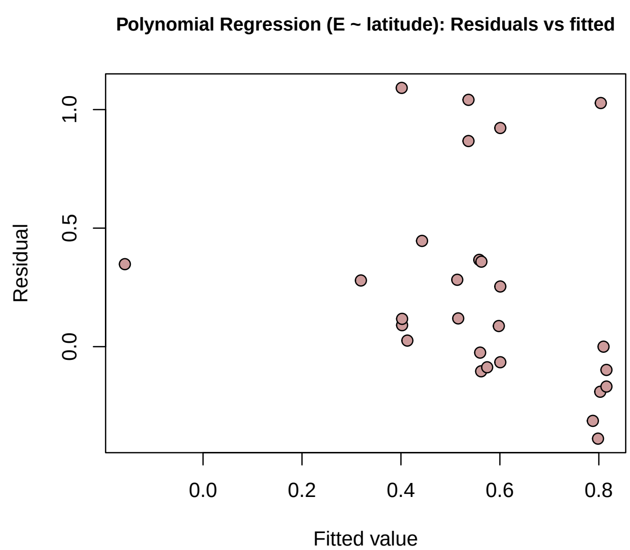

Figure S6: Residual vs fitted value for $E \sim$ Latitude polynomial model

2.2 $E \sim$ Size

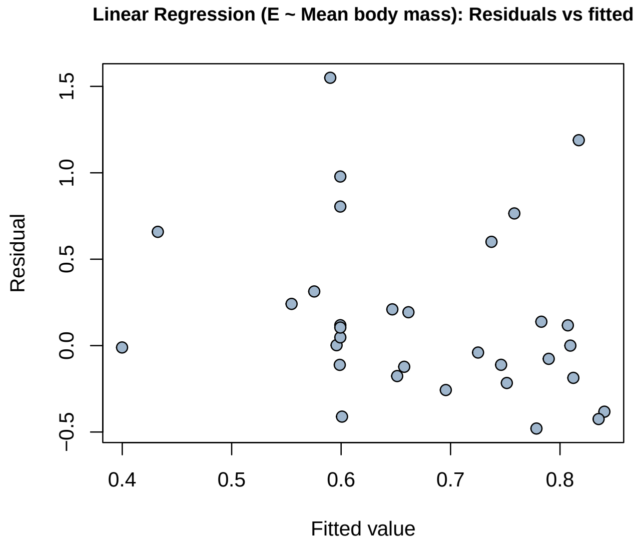

Figure S7: Residual vs fitted value for $E \sim$ Size linear model

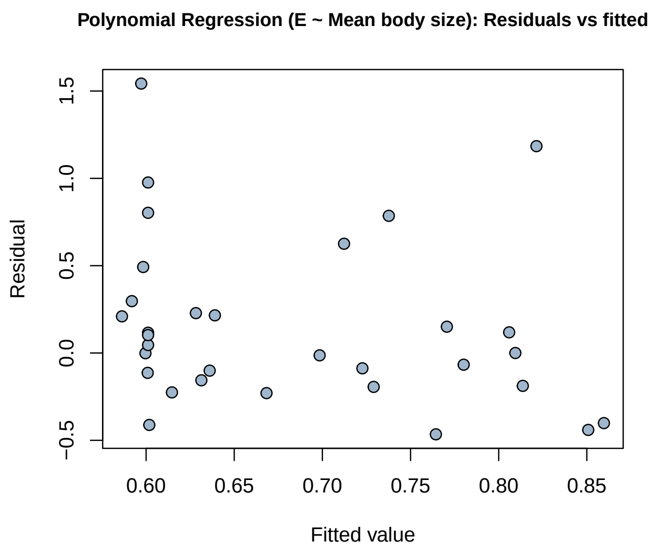

Figure S8: Residual vs fitted value for $E \sim$ Size polynomial model

2.3 $E \sim$ Latitude $\times$ Size

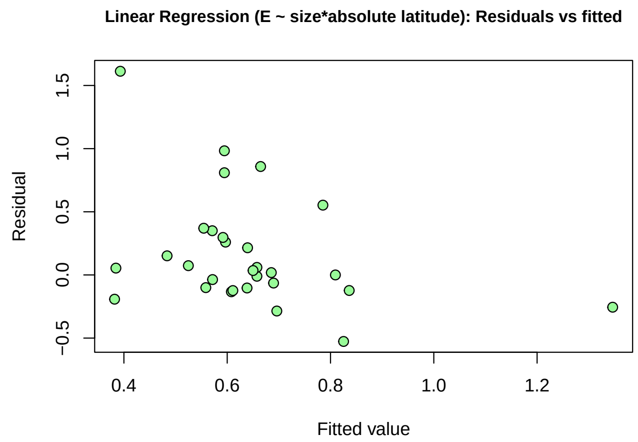

Figure S9: Residual vs fitted value for $E \sim$ Latitude *times* Size linear model

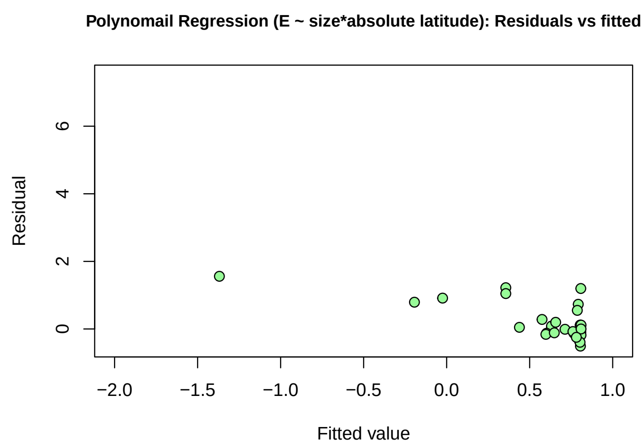

Figure S10: Residual vs fitted value for $E \sim$ Size polynomial model

3 Metabolic Rates

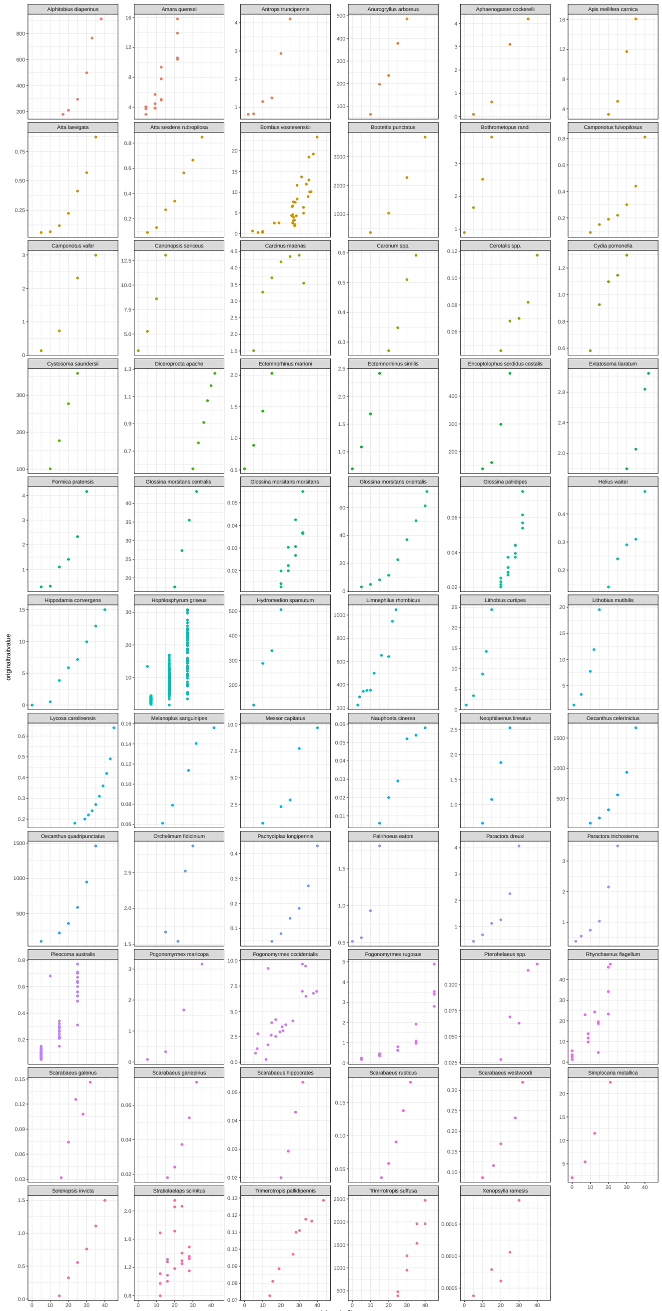

Figure S11: Metabolic rate for each species. The x-axis is temperature and metabolic rate is the y-axis. Each plot corresponds to a different species

4 Data Collection

Study	DOI
Bojrge et al. 2018. "Role of temperature on growth & metabolic rate...". J. Insect Physiol. 107	10.1016/j.jinsphys.2018.02.010
Stromme et al. 1986. "Physiological adaptations in Coleoptera on Spitsbergen". Polar Research 4	10.3402/polar.v4i2.6932
Chown 1997. "Thermal sensitivity of oxygen uptake of Diptera from sub-Antarctic..." Polar Biol 17:1	10.1007/s003000050108
Prestwich & Walker. 1981. "Energetics of singing in crickets...". Journal of comparative physiology. 143	10.1007/BF00797699
Nielsen. 1986. "Respiratory rates of ants from different climatic areas". Journal of Insect Physiology. 32:2	10.1016/0022-1910(86)90131-9
Schmolz et al. 2002. "Calorimetric investigations on metabolic rates...". Thermochimica Acta 382	10.1016/S0040-6031(01)00740-7
Beraldo & Mendes 1982. "The influence of temperature on oxygen..." Comp. Biochem. Physiol. A: Physiol 71:3	10.1016/0300-9629(82)90428-5
Kammer & Heinrich 1974. "Metabolic rates related to muscle activity in bumblebees". JEB 61:1	10.1242/jeb.61.1.219
Lozier et al. 2021. "Divergence in body mass wing loading & population structure....". Insect Syst & Div 5:5	10.1093/isd/ixab012
Mispagel. 1978. "The Ecology & Bioenergetics of the Acridid Grasshopper...." Ecology. 59:4.	10.2307/1938782
Klok & Chown. 2005. "Temperature & body mass related variation...". Insect Physiol. 51.	10.1016/j.jinsphys.2005.03.007
Lighton. 1989. "Individual & Whole-Colony Respiration in an African Formicine Ant". Functional Ecology. 3:5.	10.2307/2389566
Halsey et al. "The interactions between temperature & activity levels ...". 2014, Oecologia 177	10.1007/s00442-014-3190-5
Duncan & Dickman 2001. "Respiratory patterns & metabolism in tenebrionid...". Oecologia 129:4	10.1007/s004420100772
van Hook 1971. "Energy & Nutrient Dynamics of Spider & Orthopteran...". Ecol. Monogr 41:1	10.2307/1942433
Neven 1998. "Respiratory Response of Fifth-Instar Codling Moth...". J Econ. Entomol. 91:1	10.1093/jee/91.1.302
Boivin 2001. "Pleiotropy of insecticide resistance in the codling moth..." Entomol. Exp. Appl. .99:3	10.1046/j.1570-7458.2001.00838.x
Mac Nally & Doolan. 1982. "Comparative Reproductive Energetics....". Oikos. 39:2	10.2307/3544483
Hadley et al. 1991. "Evaporative Cooling in the Desert Cicada...". J. Exp. Biol. 159:1.	10.1242/jeb.159.1.269
Bailey & Riegert 1973. "Energy dynamics of Encoptolophus sordidus costalis...". Can. J. Zool. 51:1	10.1139/z73-014
Hill 2019. "Impacts of temperature on metabolic rates...". Physiol. Entomol. 45:1	10.1111/phen.12310
Jensen & Nielsen. 1975. "The influence of body size & temperature on worker ant respiration". Nat. Jutl.. 18.	10.1007/BF02229253
Terblanche & Chown 2007. "The effects of temperature, body mass & feeding...". Physiol. Entomol. 32:2	10.1111/j.1365-3032.2006.00549.x
Terblanche et al. 2005. "Temperature-dependence of metabolic rate...". J. Insect Physiol. 51:8	10.1016/j.jinsphys.2005.03.017
Rajagopal & Bursell. 1965. "The Respiratory Metabolism ...". Journal of Insect Physiology. 12:3	10.1016/0022-1910(66)90144-2
Terblanche et al. 2009. "Directional evolution of the slope...". Physiol. Biochem. Zool 82:5	10.1086/605361
Terblanche et al. 2006. "Phenotypic plasticity & geographic variation..." Am J Trop Med Hyg. 74:5	10.4269/ajtmh.2006.74.786
Acar et al. 2001. "Use of Calorespirometry to Determine Effects of Temperature...". Environ. Entomol. 30:5	10.1603/0046-225X-30.5.811
Katsarou et al. 2005. "Effect of temperature on development growth & feeding ...". BioControl 50:565Ð588	10.1007/s10526-004-2838-1
Nespolo et al. 2003. "Intrapopulational variation in the standard metabolic rate of insects ...". Exp. Biol. 206.	10.1242/jeb.00687
Somme et al. 1989. "Respiratory metabolism of Hydromedion sparsutum...". Polar Biol. 10	10.1007/BF00239158
Roux 1979. "The influence of some ecological factors...". Freshw. Biol. 9:2	10.1111/j.1365-2427.1979.tb01495.x
Pennington & Meehan 2007. "Influence of Body Size & Environmental Temperature...". Environ. Entomol. 36:4	10.1093/ee/36.4.673
Moeur & Eriksen 1972. "Metabolic Responses to Temperature of a Desert Spider..."Physiol. Zool. 45:4	10.1086/physzool.45.4.30155585
Chappel 1983. "Metabolism & thermoregulation in desert & montane grasshoppers". Oecologia 56:126-131.	10.1007/BF00378228
Nielsen & Baroni Urbani. 1990. "Energetics & foraging behaviour of...". Physiological Entomology. 15.	10.1111/j.1365-3032.1990.tb00533.x
Schimpf et al. 2012. "Standard metabolic rate is associated with gestation duration...". Biol. Open 1:12	10.1242/bio.20122683
Hinton. 1971. "Energy Flow in a Natural Population of Neophilaenus lineatus (Homoptera)". Oikos. 22:2.	10.2307/3543722
Smalley 1960. "Energy flow of a salt marsh grasshopper" Pop. Ecol. 41:4	10.2307/1931800
Lavy & Verhoef 1996. "Effects of food quality on growth & body composition...". Physiol. Entomol. 21:1	10.1111/j.1365-3032.1996.tb00836.x
May. 1978. "Energy metabolism of dragonflies (Anisoptera)...". Exp. Biol. 83.	10.1242/jeb.83.1.79
Mercer et al. 2001. "Invertebrate body sizes from Marion Island". Antarct. Sci. 13:2	10.1017/S0954102001000219
Sustr & Stary 1998. "Digestive enzymes in oribatid mites...". Pedobiologia 38:250-253	NA
Morgan. 1987. "Temp. Regulation Energy Metabolism & Mate-Searching...". Exp. Biol. 128:1.	10.1242/jeb.128.1.107
Rogers et al. 1972. "Bioenergetics of the Western Harvester Ant...". Environ. Entomol. 1:6	10.1093/ee/1.6.763
Ettershank & Whitford. 1973. "O2 of two species of Pogonomyrmex ...". Comp. Biochem. Physiol. 46:3.	10.1016/0300-9629(73)90111-4
Chown & Davis. "Discontinuous gas exchange & the significance of respiratory water loss...". JEB 206:20	10.1242/jeb.00603
Davis et al. 2000. "A comparative analysis of metabolic rate in six Scarabaeus ..." J. Insect. Physiol. 46:4	10.1016/S0022-1910(99)00141-9
Elzen 1986. "Oxygen consumption & water loss in the imported fire ant...". Comp. Biochem. & Physiol. A: 84:1	10.1016/0300-9629(86)90035-6
Meehan et al. 2022. "Predators minimize energy costs rather than maximize energy gains". Funct. Ecol.	10.1111/1365-2435.14131
Massion. 1983. "An altitudinal comparison of water & metabolic relations...". Comp Biochem Physiol. 74A:1	10.1016/0300-9629(83)90719-3
Fielden et al. 2004. "Respiratory gas exchange in the desert fle... ". Comp. Biochem. Physiol. 137:3.	10.1016/j.cbpb.2003.11.012

Table S2: Table containing citation and DOI for each study included in the analysis. From these studies, metabolic rate data for 142 species from 48 families was measured across temperature ranges and collected along with information on life stage, experimental conditions, sex, body size, location and accumilation temperature

References

Dimitrios—Georgios Kontopoulos, Thomas P Smith, Timothy G Barraclough, and Samraat Pawar. Adaptive evolution shapes the present-day distribution of the thermal sensitivity of population growth rate. *PLoS biology*, 18(10):e3000894, 2020.