

S1: Supplementary Information

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1. Supplementary Methods

(a) Species included in the datasets

Most species included in the parasite and behaviour databases match the Corbet & Hill (C&H) taxonomy [1], with the following exceptions: five lemur species in the genus *Eulemur* were indexed under the alternate C&H genus of *Petterus*; the

howler monkey, *Alouatta pigra* was indexed under the alternate C&H species designation of *Alouatta villosa*; and two species, *Alouatta guariba* and *Callicebus personatus*, were not identified in the C&H system. Species are listed by alphabetical order in Appendix S-A.

Appendix S-A. List of primate species included in the parasite and behaviour database, according to the Corbet & Hill taxonomy [1]. Species marked with asterisks indicate minor changes from the original taxonomies used in data collection (as noted in ESM Section 1a).

Corbet & Hill Species			
<i>Allenopithecus nigroviridis</i>	<i>Cercopithecus ascanius</i>	<i>Hylobates concolor</i>	<i>Pan paniscus</i>
<i>Alouatta belzebul</i>	<i>Cercopithecus campbelli</i>	<i>Hylobates hoolock</i>	<i>Pan troglodytes</i>
<i>Alouatta caraya</i>	<i>Cercopithecus cephus</i>	<i>Hylobates lar</i>	<i>Papio anubis</i>
<i>Alouatta guariba</i> *	<i>Cercopithecus diana</i>	<i>Hylobates moloch</i>	<i>Papio cynocephalus</i>
<i>Alouatta palliata</i>	<i>Cercopithecus lhoesti</i>	<i>Hylobates syndactylus</i>	<i>Papio hamadryas</i>
<i>Alouatta villosa</i> *	<i>Cercopithecus mitis</i>	<i>Indri indri</i>	<i>Papio papio</i>
<i>Alouatta seniculus</i>	<i>Cercopithecus mona</i>	<i>Lagothrix lagotricha</i>	<i>Papio ursinus</i>
<i>Aotus azarae</i>	<i>Cercopithecus neglectus</i>	<i>Lemur catta</i>	<i>Perodicticus potto</i>
<i>Aotus trivirgatus</i>	<i>Cercopithecus nictitans</i>	<i>Leontopithecus chrysomelas</i>	<i>Pithecia irrorata</i>
<i>Arctocebus calabarensis</i>	<i>Cercopithecus petaurista</i>	<i>Leontopithecus chrysopygus</i>	<i>Pithecia pithecia</i>
<i>Ateles belzebuth</i>	<i>Cercopithecus pogonias</i>	<i>Leontopithecus rosalia</i>	<i>Pongo pygmaeus</i>
<i>Ateles fusciceps</i>	<i>Cercopithecus preussi</i>	<i>Lepilemur mustelinus</i>	<i>Presbytis cristata</i>
<i>Ateles geoffroyi</i>	<i>Cheirogaleus major</i>	<i>Macaca arctoides</i>	<i>Presbytis entellus</i>
<i>Ateles paniscus</i>	<i>Cheirogaleus medius</i>	<i>Macaca assamensis</i>	<i>Presbytis melalophos</i>
<i>Avahi laniger</i>	<i>Colobus angolensis</i>	<i>Macaca cyclopis</i>	<i>Presbytis obscura</i>
<i>Brachyteles arachnoides</i>	<i>Colobus badius</i>	<i>Macaca fascicularis</i>	<i>Presbytis phayrei</i>
<i>Cacajao calvus</i>	<i>Colobus guereza</i>	<i>Macaca fuscata</i>	<i>Presbytis vetulus</i>
<i>Callicebus moloch</i>	<i>Colobus polykomos</i>	<i>Macaca maurus</i>	<i>Propithecus diadema</i>
<i>Callicebus personatus</i> *	<i>Daubentonia madagascariensis</i>	<i>Macaca mulatta</i>	<i>Propithecus tattersalli</i>
<i>Callimico goeldii</i>	<i>Erythrocebus patas</i>	<i>Macaca nemestrina</i>	<i>Propithecus verreauxi</i>
<i>Callithrix argentata</i>	<i>Petterus coronatus</i> *	<i>Macaca nigra</i>	<i>Saguinus fuscicollis</i>
<i>Callithrix jacchus</i>	<i>Petterus fulvus</i> *	<i>Macaca ochreata</i>	<i>Saguinus leucopus</i>
<i>Cebuella pygmaea</i>	<i>Petterus macaco</i> *	<i>Macaca radiata</i>	<i>Saguinus midas</i>
<i>Cebus albifrons</i>	<i>Petterus mongoz</i> *	<i>Macaca sinica</i>	<i>Saguinus mystax</i>
<i>Cebus apella</i>	<i>Petterus rubriventer</i> *	<i>Macaca sylvanus</i>	<i>Saguinus oedipus</i>
<i>Cebus capucinus</i>	<i>Euoticus elegantulus</i>	<i>Macaca tonkeana</i>	<i>Saimiri boliviensis</i>
<i>Cebus olivaceus</i>	<i>Galago moholi</i>	<i>Mandrillus leucophaeus</i>	<i>Saimiri oerstedii</i>
<i>Cercocebus albigena</i>	<i>Galago senegalensis</i>	<i>Mandrillus sphinx</i>	<i>Saimiri sciureus</i>
<i>Cercocebus aterrimus</i>	<i>Galagoides demidoff</i>	<i>Microcebus murinus</i>	<i>Tarsius bancanus</i>
<i>Cercocebus galeritus</i>	<i>Gorilla gorilla</i>	<i>Miopithecus talapoin</i>	<i>Theropithecus gelada</i>
<i>Cercocebus torquatus</i>	<i>Hapalemur griseus</i>	<i>Nycticebus coucang</i>	<i>Varecia variegata</i>
<i>Cercopithecus aethiops</i>	<i>Hapalemur simus</i>	<i>Otolemur crassicaudatus</i>	

Table S1. Results of a minimal Bayesian PGLS models, run independently for both innovation and extractive foraging. Parasite species richness was the response variable and all others (behaviour richness, body mass, group size, and geographic range) were predictors; terrestriality and absolute latitude were excluded from these initial tests. Reported outputs for each predictor are the mean slopes (β) and proportion of models with positive slopes (support) sampled from 3,000,000 iterations. Model mean R^2 and mean λ were estimated as the means of all iterations and 95% highest posterior density credibility intervals (95% HPD CI) values for λ were calculated from all results. Innovation and extractive foraging models converge to nearly identical results for each variable studied, justifying the combination of the two into a single variable.

Parasite Transmission Mode	Behavioural Measure	Behaviour Richness		Body Mass		Group Size		Geographic Range		Lambda		Mean R^2
		Mean β	Support	Mean β	Support	Mean β	Support	Mean β	Support	Mean λ	95% HPD CI	
All	Innovation	0.21	98.9%	0.22	99.9%	0.05	74.3%	0.05	92.2%	0.20	<0.01 - 0.47	0.17
All	Extractive Foraging	0.20	97.6%	0.22	99.8%	0.04	68.2%	0.06	92.9%	0.22	<0.01 - 0.51	0.16

(b) Justification for combining innovation and extractive foraging

To facilitate simpler and more intuitive interpretations of the hypotheses given in the introduction of the paper, we combined innovation and extractive foraging counts for each species. Because each of these measures separately quantified an aspect of exploration, we investigated whether it would be justified to combine these two variables into a single variable describing exploratory behaviour as a whole. Results of separate MCMC Bayesian PGLS models for innovation and extractive foraging regressed against parasite species richness, controlling for common covariates, showed converging results (Table S1), and were thus combined into a single variable for analyses presented in the main text.

(c) Further details of the behavioural dataset

Behavioural data were obtained from [3], a survey of over 4000 articles published between 1925-2000, principally coming from four primate behaviour journals (*Primates*, *American Journal of Primatology*, *Folia Primatologica*, and *the International Journal of Primatology*), but also from searches of other relevant literature and studies cited by publications that were located in the first round of search. Keywords were used to classify behaviour patterns. Innovation was defined as the discovery of novel solutions to environmental or social problems (example keywords: “innovation”, “invention”, “opportunistic”, “departure from normal behavioural repertoire”, “not previously observed”, “unusual”, “no published accounts”, “first observation”, “unique”, “exceptional”, “previously unreported”, “not documented before”, “never seen before”, “novel”, “new”). Extractive foraging was defined as feeding on foods that must first be extracted from matrices in which they are embedded or encased, including nutmeat, shellfish, snails, eggs, brains, bone marrow, roots, tubers, and ant and termite mounds. Social learning was defined as learning skills and acquiring information from others (example keywords: “social learning”, “social transmission”, “cultural transmission”, “traditional”, “teaching”, “imitation”, “protoculture”, “[goal

emulation”, “observational learning”, “learning from each other”, “culturally acquired”, “local enhancement”, “stimulus enhancement”, “socially mediated learning”). Examples came from varied behavioural contexts, including foraging behaviour, locomotion, anti-predator behaviour and social displays. Further details of how data were collated, examples of behavioural reports, and discussion of the validation and utility of the dataset are given in [3-7].

For reports to be included in the behavioural database as distinct examples, they needed to be reported as separate behaviour patterns by the original authors. The database was then screened for possible repeated examples, with reports in the same species, context, and involving the same food and substrate only counted once. For example, two reports in one species of fracturing dead branches to consume larvae would be counted only once, whereas two reports, one of fracturing branches to consume larvae and another of fracturing branches to access fungi would be counted as two reports. Similarly, digging soil to access larvae and fracturing branches to access larvae would count as two reports. Thus a specialist extractive forager that uses a single extractive foraging technique to access a foodstuff would only be counted for one report in our database. Inter-observer reliabilities are high, and the measures have been validated against other compilations as well as against experimental cognitive tests [3,5,8]. Our behavioural data provide a measure of the variety of reports within each behavioural category for each species, rather than data on the frequency of use, time spent, or reliance on social learning, innovation, and extractive foraging.

(d) Further details of the parasite dataset

Parasite species richness data were obtained from the Global Mammal Parasite Database (GMPD; [9]). The GMPD was collated by searching published literature for reports of parasites from wild primate populations, using online reference databases such as Biological Abstracts, AGRICOLA, Medline, PrimateLit, and Web of Science. Edited volumes, reviews, and studies that were cited by publications that were located in the

first round of searches were also examined. Latin binomials of primate species were used as search keywords, as well as primate genus name (following [1] and common taxonomic variants [10,11]). Parasites were recorded in the database following positive identification of a genus or species of parasite within a mammal host from one of these published articles; only peer-reviewed identifications were noted in the database. The database is continuously updated with new records; the dataset used for this study was extracted from the database in September 2010, and thus includes records up to this date.

2. Supplementary Results

(a) Dissociation between social learning and exploratory behaviour

Previous studies have demonstrated a positive relationship between the frequency of social learning and innovation [3]. The results presented in this study are not in conflict with these findings, as we also found such a relationship in our own analyses (Figure S1), again with a modest correlation coefficient ($R^2 = 0.23$). Such a result indicates that a large proportion of the unexplained variance must be attributable to other variables, two of which we have presented evidence for in the main text: environmentally and socially transmitted parasite species richness.

(b) Terrestriality and parasite richness

More terrestrial species may encounter a greater variety of environmentally transmitted parasites than do more arboreal primates [12,13]. However, the variable was not included as a predictor in the models presented in the main text for several reasons. First, previous comparative studies have failed to find a consistent association between general measures of parasitism and terrestriality [13]. In addition, including this variable reduced the power of the models below an acceptable level. Finally, the measure of terrestriality available for our large sample of primates [14] is a binary categorisation of what is, in reality, a continuum of tree and ground use.

However, the links between terrestriality and socially-transmitted or environmentally transmitted infectious agents have not previously been investigated. Thus, for completeness, we ran our multivariate analyses with a binary categorization of terrestriality, obtained from Nunn and van Schaik [14]. We found that substrate use predicted parasite richness, with terrestriality covarying positively with socially transmitted parasites, but not with environmentally transmitted parasites (Table S2). This result was contrary to our predictions. One reason for this may be that terrestrial primate species are in closer social and spatial contact than are arboreal species [15], an idea supported by our finding that terrestrial species demonstrate increased rates of social learning (Section S2c).

(c) Effects of terrestriality on behavioural measures

The results of strong positive associations between terrestriality and different measures of parasite transmission may have been partially due to strong associations between terrestrial habits and increased social learning. More terrestrial primate species consistently showed higher levels of both social learning (Figure S2a) and exploratory behaviour (Figure S2b), findings that may be attributable to the increased social cohesion of terrestrial species and their increased time in interaction with terrestrial substrates, respectively. Thus, terrestriality is associated with both an increased richness of socially transmitted parasites and increased rates of social learning, and an independent association exists between social learning and socially transmitted parasites even while taking terrestriality into account (Table S2).

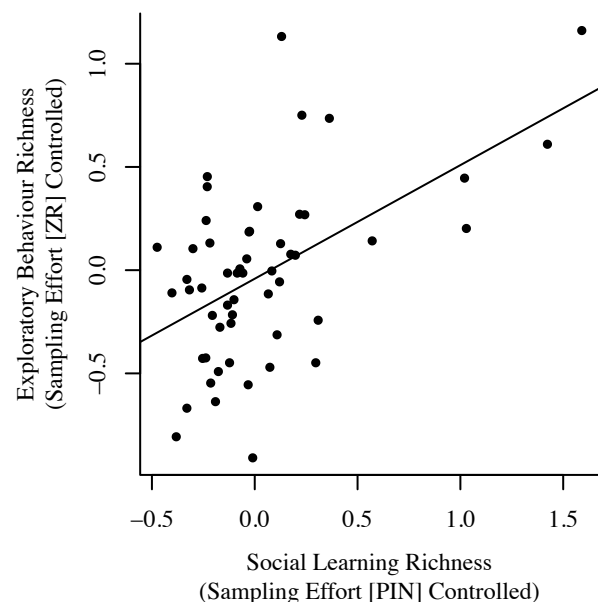


Figure S1. Association between social learning richness and exploratory behaviour richness. This figure is based on the data included in the exclusive parasite transmission mode models. The line, with a slope of 0.51 and $R^2=0.23$, indicates average results from 3,000,000 iterations of MCMC Bayesian PGLS with 99.99% of models supporting a positive association after controlling for all socio-ecological variables and research effort in the multiple regression model. Parenthetical descriptors of sampling efforts are as follows: ZR - sampling effort estimated from the Zoological Record; PIN - sampling effort estimated from Primate Information Network's "PrimateLit" database.

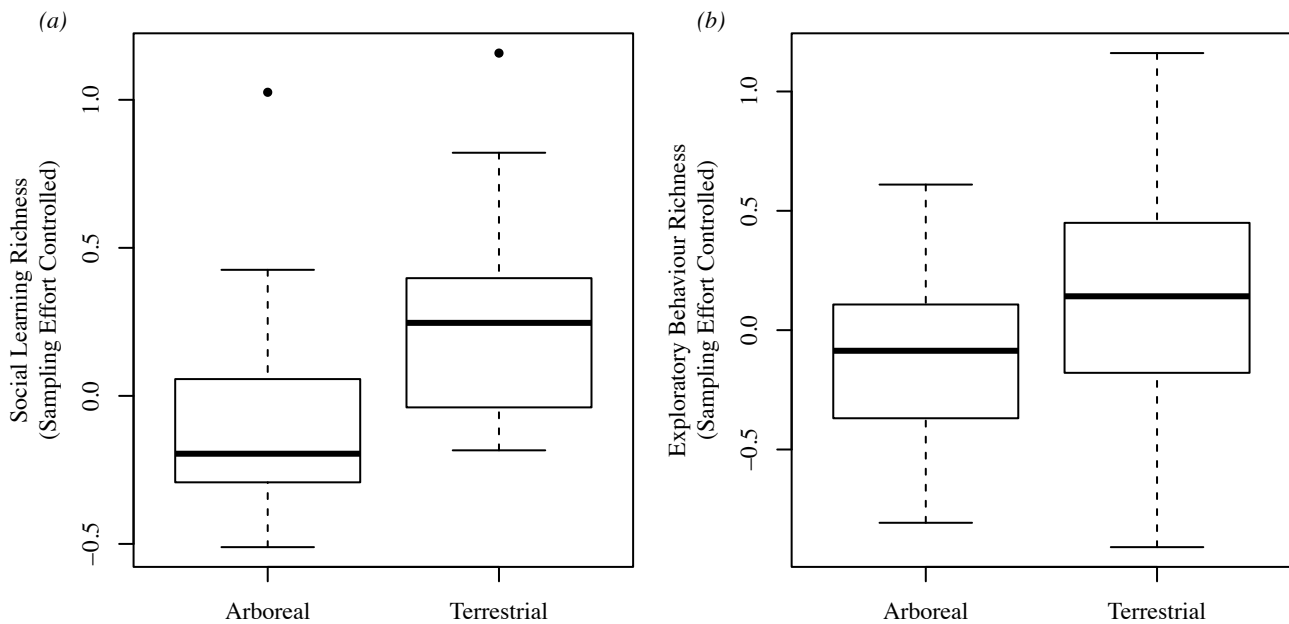


Figure S2. Effects of terrestriality on behavioural richness among primates. We investigated the effect of terrestriality on behaviour richness in the exclusive parasite transmission mode models. Primate species were categorized as either arboreal or terrestrial. There were significantly more reports of both social learning (A; Support=99.3%) and exploratory behaviour (B; Support=94.8%) in terrestrial compared to arboreal primates. Box plots indicate median line, 25th and 75th percentile, with whiskers denoting the 1.5 interquartile range and points indicating outliers.

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Table S2. Results of the four mutually exclusive transmission mode Bayesian PGLS models, including terrestriality. Parasite species richness was the response variable and all others (behaviour richness, terrestriality, body mass, group size, geographic range, and absolute latitude) were predictors. Reported outputs for each predictor are the mean slopes (β) and proportion of models with predicted slopes (support) from 3,000,000 iterations. Model mean R^2 and mean λ were estimated as the means of all iterations and 95% highest posterior density credibility intervals (95% HPD CI) values for λ were calculated from all results.

Parasite Transmission Mode	Behavioural Measure	Behaviour Richness		Terrestriality		Body Mass		Group Size		Geographic Range		Absolute Latitude		Lambda		Mean R^2
		Mean β	Support	Mean β	Support	Mean β	Support	Mean β	Support	Mean β	Support	Mean β	Support	Mean λ	95% HPD CI	
<i>Social</i>	<i>Exploration</i>	-0.04	26.50%	0.14	97.50%	0.14	99.00%	-0.1	5.20%	0.09	99.10%	-0.01	75.60%	0.21	<0.01 - 0.48	0.26
<i>Social</i>	<i>Social Learning</i>	0.13	94.40%	0.1	91.80%	0.11	97.10%	-0.08	11.70%	0.08	98.20%	-0.02	80.70%	0.19	<0.01 - 0.46	0.29
<i>Environmental</i>	<i>Exploration</i>	0.11	90.00%	0.09	82.80%	0.1	86.90%	0.03	65.20%	-0.01	43.60%	-0.03	87.60%	0.2	<0.01 - 0.50	0.12
<i>Environmental</i>	<i>Social Learning</i>	<0.01	51.20%	0.11	86.20%	0.12	92.50%	0.02	57.50%	<0.01	50.90%	-0.03	84.80%	0.22	<0.01 - 0.53	0.09
<i>Total</i>	<i>Total</i>	0.2	99.80%	-0.08	14.80%	0.11	94.20%	0.06	79.70%	0.07	96.00%	-0.04	97.80%	0.29	<0.01 - 0.55	0.16