

Supplementary table S1: List and references of social systems in lamprologini cichlids endemic to Lake Tanganyika. CSV data are available at Dryad. References are shown in end of this file.

Species	Taxon names in Ronco et al. 2021	Breeding habitat	Social system	Reference(s)
<i>Altolamprologus calvus</i>	Altcal	facultative shell-brooder	Noncooperative breeder	1
<i>Altolamprologus compressiceps</i>	Altcom	facultative shell-brooder	Noncooperative breeder	1
<i>Chalinochromis brichardi</i>	Chabri	crevices and caves	cooperative breeder	M. Kohda (personal observation), 2,3
<i>Chalinochromis popelini</i>	Chapop	crevices and caves	cooperative breeder	2,3,
<i>Julidochromis transcriptus</i>	Juktra	crevices and caves	cooperative breeder	2,3
<i>Julidochromis dickfeldi</i>	Juldic	crevices and caves	cooperative breeder	2
<i>Julidochromis</i> sp. "Kombe"	Julkom	crevices and caves	cooperative breeder	M. Morita (personal observation)
<i>Julidochromis marlieri</i>	JulmaS/JulmaN	crevices and caves	cooperative breeder	4,5
<i>Julidochromis ornatus</i>	Julorn	crevices and caves	cooperative breeder	6
<i>Julidochromis regani</i>	Julreg/JulreK	crevices and caves	cooperative breeder	1,2,3
<i>Lamprologus callipterus</i>	Lamcal	rocky area	Noncooperative breeder	7
<i>Lamprologus kungweensis</i>	Lamkun	shell-brooder	Noncooperative breeder	1
<i>Lamprologus laparogramma</i>	Lamlap	sandy or muddy area	Noncooperative breeder	Satoh personal observation, 1
<i>Lamprologus lemairii</i>	Lamlem	rocky area	Noncooperative breeder	8
<i>Lamprologus meleagris</i>	Lammel	shell-brooder	Noncooperative breeder	1
<i>Lamprologus ocellatus</i>	Lamoce	shell-brooder	Noncooperative breeder	1,9
<i>Lamprologus ornatipinnis</i>	Lamorn/LamorC/LamorS	shell-brooder	Noncooperative breeder	1,10,11
<i>Lamprologus signatus</i>	Lamsig	sandy or muddy area	Noncooperative breeder	1
<i>Lamprologus speciosus</i>	Lamspe	shell-brooder	Noncooperative breeder	12
<i>Lepidiolamprologus attenuatus</i>	Lepatt	facultative shell-brooder	Noncooperative breeder	13
<i>Lepidiolamprologus cunningtoni</i>	Lepcun	sandy or muddy area	Noncooperative breeder	Satoh personal observation; 1
<i>Lepidiolamprologus elongatus</i>	Lepelo	rocky area	Noncooperative breeder	1,14
<i>Lepidiolamprologus kamambae</i>	Lepkam	rocky area	Noncooperative breeder	1
<i>Lepidiolamprologus kendalli</i>	Lepken	rocky area	Noncooperative breeder	Satoh personal observation,1
<i>Lepidiolamprologus profundicola</i>	Leppro	rocky area	Noncooperative breeder	1
<i>Neolamprologus bifasciatus</i>	Neobif	rocky area	cooperative breeder	15
<i>Neolamprologus boulengeri</i>	Neobou	shell-brooder	Noncooperative breeder	1
<i>Neolamprologus brevis</i>	Neobre/NeobrM	facultative shell-brooder	Noncooperative breeder	16
<i>Neolamprologus brichardi</i>	Neobri	rocky area	cooperative breeder	see the references in main text

Species	Taxon names in Ronco et al. 2021	Breeding habitat	Social system	Reference(s)
<i>Neolamprologus buescheri</i>	Neobue	crevices and caves	cooperative breeder	2,17
<i>Neolamprologus calliurus</i>	Neocal	facultative shell-brooder	Noncooperative breeder	2,16
<i>Neolamprologus caudopunctatus</i>	Neocau/NeocaK	facultative shell-brooder	Noncooperative breeder	1
<i>Neolamprologus chitamwebwai</i>	Neochi	rocky area	cooperative breeder	19
<i>Neolamprologus christyi</i>	Neochr	rocky area	Noncooperative breeder	1
<i>Neolamprologus crassus</i>	Neocra	rocky area	cooperative breeder	2
<i>Neolamprologus cylindricus</i>	Neocyl	crevices and caves	Noncooperative breeder	1
<i>Neolamprologus falcicula</i>	Neofal/NeofaM	rocky area	cooperative breeder	2,3
<i>Neolamprologus fasciatus</i>	Neofas	facultative shell-brooder	Noncooperative breeder	1
<i>Neolamprologus furcifer</i>	Neofur/NeofuU	rocky area	Noncooperative breeder	20,21,22
<i>Neolamprologus gracilis</i>	Neogra/NeogrM	rocky area	cooperative breeder	2,23
<i>Neolamprologus helianthus</i>	Neohel	rocky area	cooperative breeder	2
<i>Neolamprologus</i> sp. "Kombe"	Neokom	rocky area	cooperative breeder	M. Morita (personal observation)
<i>Neolamprologus leleupi</i>	NeoleL	rocky area	Noncooperative breeder	1
<i>Neolamprologus marunguensis</i>	Neomar	rocky area	cooperative breeder	2
<i>Neolamprologus meeli</i>	Neomee	shell-brooder	cooperative breeder	24
<i>Neolamprologus modestus</i>	Neomod	rocky area	Noncooperative breeder	1
<i>Neolamprologus mondabu</i>	Neomon	rocky area	Noncooperative breeder	1
<i>Neolamprologus multifasciatus</i>	Neomul	shell-brooder	cooperative breeder	2;25,26
<i>Neolamprologus mustax</i>	Neomux	rocky area	Noncooperative breeder	1,27
<i>Neolamprologus niger</i>	Neonig	rocky area	cooperative breeder	2
<i>Neolamprologus nigriventris</i>	Neonve	rocky area	Noncooperative breeder	2
<i>Neolamprologus obscurus</i>	Neoobs	rocky area	cooperative breeder	28,29
<i>Neolamprologus olivaceus</i>	Neoli	rocky area	cooperative breeder	2
<i>Neolamprologus pleuromaculatus</i>	Neople	crevices and caves	Noncooperative breeder	1
<i>Neolamprologus prochilus</i>	Neopro	rocky area	Noncooperative breeder	1
<i>Neolamprologus pulcher</i>	Neopul	rocky area	cooperative breeder	see the references in main text
<i>Neolamprologus savoyi</i>	Neosav	rocky area	cooperative breeder	see the references in main text
<i>Neolamprologus sexfasciatus</i>	Neosex	rocky area	Noncooperative breeder	1
<i>Neolamprologus similis</i>	Neosim	shell-brooder	cooperative breeder	2,30
<i>Neolamprologus splendens</i>	Neospl	NA	cooperative breeder	2
<i>Neolamprologus tetracanthus</i>	Neotet	rocky area	Noncooperative breeder	2
<i>Neolamprologus timidus</i>	Neotim	rocky area	Noncooperative breeder	1,10,11
<i>Neolamprologus toae</i>	Neotoa	rocky area	Noncooperative breeder	31
<i>Neolamprologus tretocephalus</i>	Neotre	rocky area	Noncooperative breeder	32
<i>Neolamprologus walteri</i>	Neowal	rocky area	cooperative breeder	19
<i>Telmatochromis bifrenatus</i>	Telbif	rocky area	Noncooperative breeder	1,2
<i>Telmatochromis dhonti</i>	TeldhS/TeldhT/TeldhN	rocky area	Noncooperative breeder	1
<i>Telmatochromis temporalis</i>	Teltem	shell-brooder	Noncooperative breeder	33
<i>Telmatochromis vittatus</i>	Telvit	facultative shell-brooder	Noncooperative breeder	34
<i>Variabilichromis moorii</i>	Varmoo	rocky area	Noncooperative breeder	35,36

Supplementary table S2: Factors influencing social system (cooperative or non-cooperative breeding) in Lamprologini cichlids endemic to Lake Tanganyika analyzed using a phylogenetic generalized linear model (PGLM). *Neolamprologus niger*, a basal species with an incompletely described social system, was treated as a cooperative breeder in this analysis (n = 61 species).

Explanatory variables	Estimate $\pm$ SE	<i>z</i>	<i>p</i>
Log total length	12.99 $\pm$ 5.33	2.44	0.015
Crevices and caves	-12.71 $\pm$ 5.38	-2.36	0.018
Facultative shell-brooding	-4.62 $\pm$ 2.29	-2.02	0.043
Rocky area	-2.80 $\pm$ 1.33	-2.11	0.035
Sandy/muddy area	-4.38 $\pm$ 2.73	-1.60	0.109
Obligatory shell-brooder	-4.00 $\pm$ 1.96	-2.04	0.042

Supplementary table S3: Factors influencing social system (cooperative or non-cooperative breeding) in Lamprologini cichlids endemic to Lake Tanganyika analyzed using a phylogenetic generalized linear model (PGLM). *Neolamprologus niger*, a basal species with an incompletely described social structure, was treated as a non-cooperative breeder in this analysis (n = 61 species).

Explanatory variables	Estimate $\pm$ SE	<i>z</i>	<i>p</i>
Log total length	-11.45 $\pm$ 4.68	-2.45	0.014
Crevices and caves	12.25 $\pm$ 4.80	2.55	0.011
Facultative shell-brooding	7.18 $\pm$ 3.92	1.83	0.067
Rocky area	9.43 $\pm$ 4.22	2.24	0.025
Sandy/muddy area	7.26 $\pm$ 3.70	1.96	0.050
Obligatory shell-brooder	8.14 $\pm$ 3.47	2.34	0.019

Supplementary table S4: Factors influencing social system (cooperative or non-cooperative breeding) in Lamprologini cichlids endemic to Lake Tanganyika analyzed using a phylogenetic generalized linear model (PGLM). *Neolamprologus niger*, a basal species with an incompletely described social structure, was excluded from this analysis (n = 60 species).

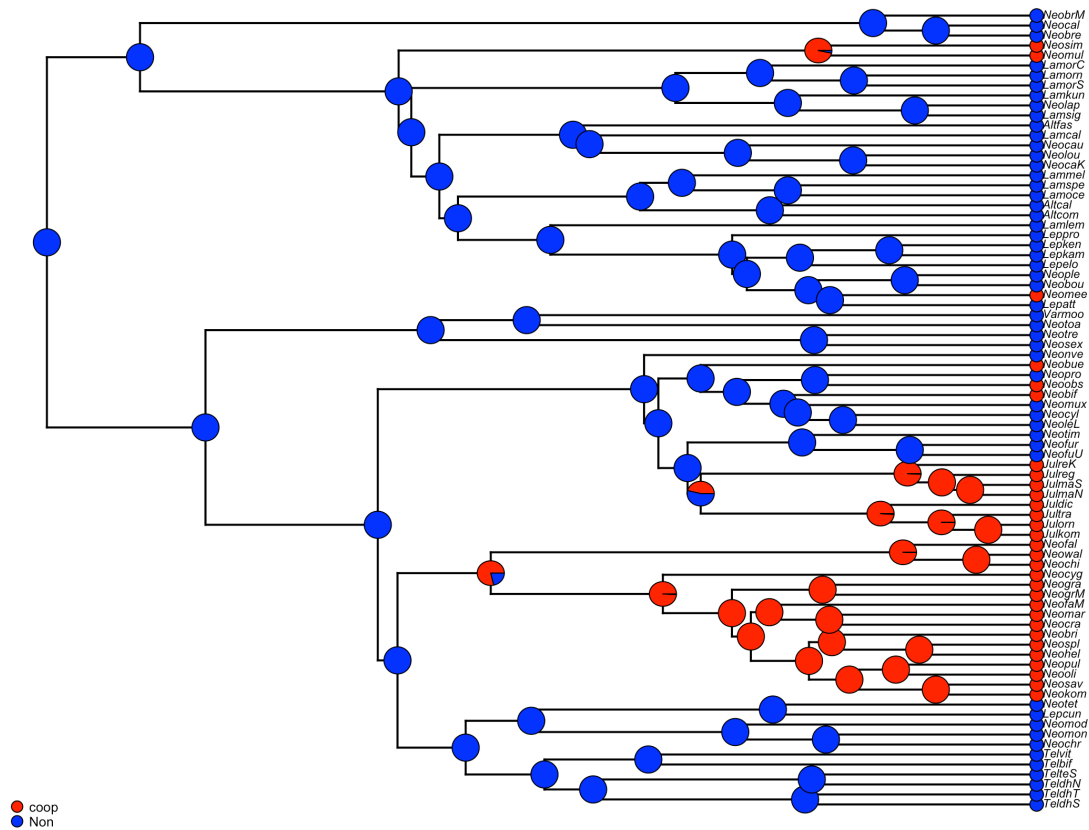
Explanatory variables	Estimate $\pm$ SE	z	p
Log total length	13.18 $\pm$ 5.26	2.50	0.012
Crevices and caves	-12.59 $\pm$ 5.16	-2.44	0.015
Facultative shell-brooding	-4.92 $\pm$ 2.28	-2.16	0.031
Rocky area	-3.05 $\pm$ 1.31	-2.33	0.020
Sandy/muddy area	-4.75 $\pm$ 2.80	-1.70	0.090
Obligatory shell-brooder	-4.43 $\pm$ 2.00	-2.22	0.027

Supplementary table S5: Phylogenetic signals of life history traits (male and female body weight, total length, clutch size, and egg size) in lamprologini cichlids, calculated using the average value of each species.

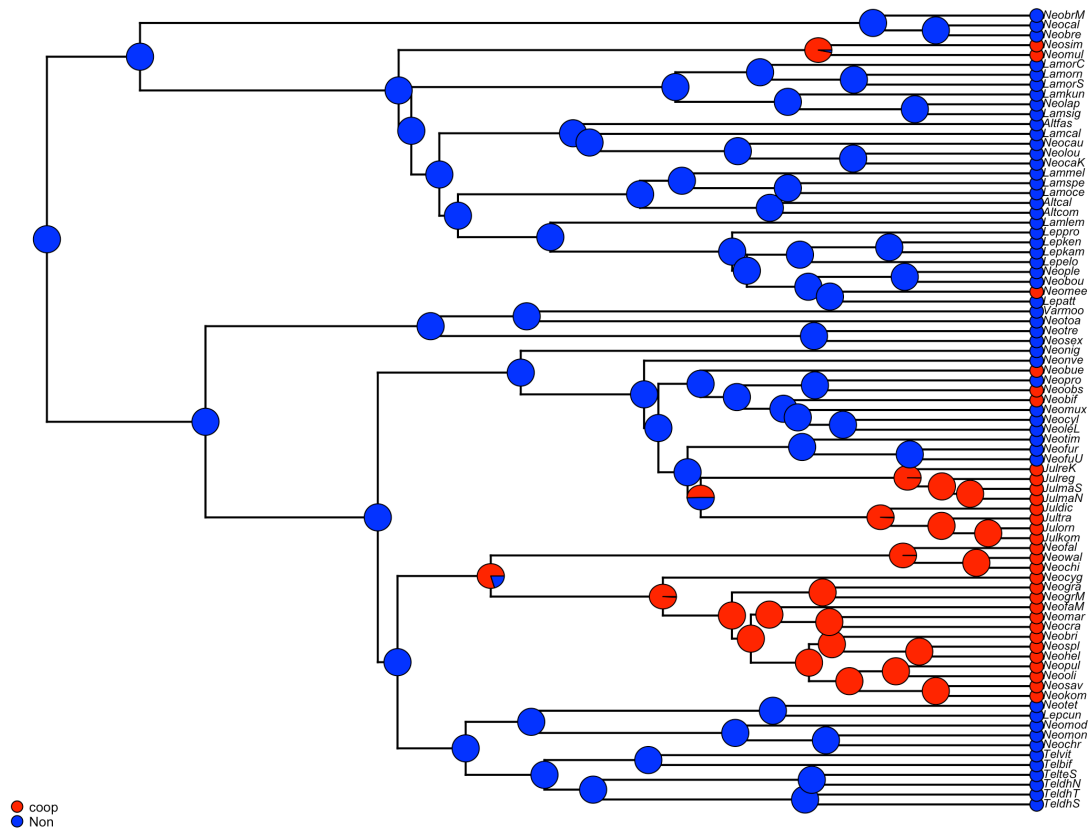
Traits	p	λ	log likelihood	log likelihood (Lambda=0)
Log male body weight	0.083	0.00008	-34.7609	-34.7606
Log female body weight	0.003	1.00510	-33.1661	-35.8820
Log mean clutch size	0.001	1.03167	-38.1779	-43.3304
Log mean egg size	0.068	0.00008	-0.2282	-0.2278
Log total length	0.001	0.95633	17.3800	11.5931

Supplementary table S6: Statistical information of phylogenetic path analysis.

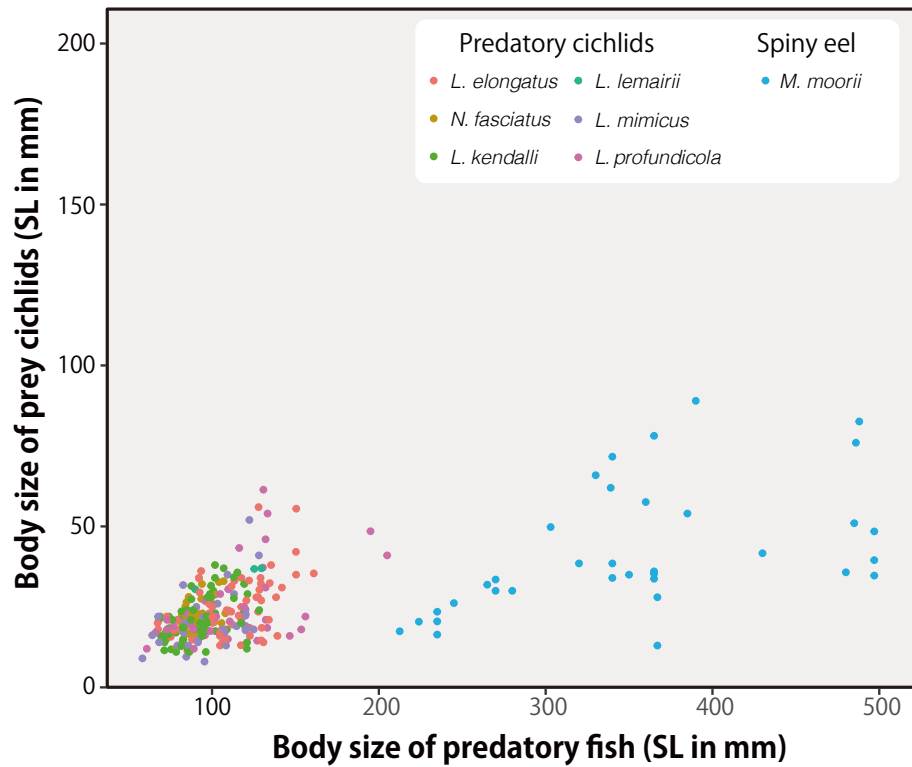
Models	C statistic	p value	CICc	Δ CICc
ACD	5.49	0.240	26.3	0
CD	9.91	0.129	27.5	1.23
ABCD	3.94	0.139	28.1	1.85
BCD	7.38	0.117	28.2	1.89
AD	21.21	0.002	38.8	12.53
ABD	19.66	< 0.001	40.5	14.17
BD	23.1	< 0.001	40.7	14.42
D	27.39	< 0.001	42	15.72
AC	30.5	< 0.001	48.1	21.82
C	34.92	< 0.001	49.5	23.25
ABC	29.11	< 0.001	49.9	23.62
BC	32.56	< 0.001	50.2	23.88
A	46.22	< 0.001	60.8	34.55
AB	44.83	< 0.001	62.4	36.15
B	48.27	< 0.001	62.9	36.61
null	52.4	< 0.001	64.2	37.92



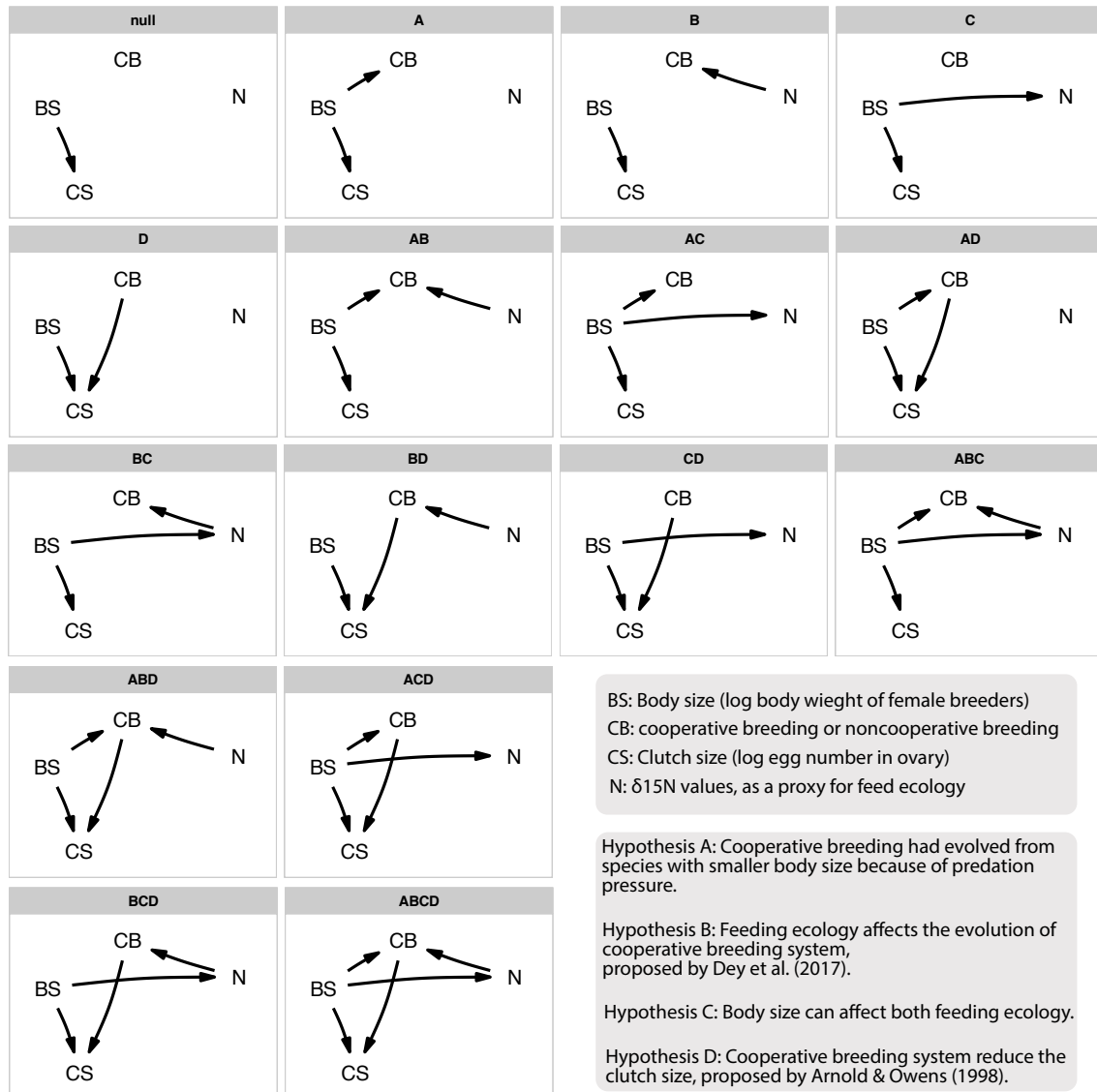
Supplementary figure S1: Results of ancestral state reconstruction for social system of lamprologini cichlids endemic to Lake Tanganyika. *Neolamprologus niger*, a basal species with an incompletely described social structure, was excluded from this analysis.



Supplementary figure S2: Results of ancestral state reconstruction for social system of lamprologini cichlids endemic to Lake Tanganyika. *Neolamprologus niger*, a basal species with an incompletely described social structure, was treated as a non-cooperative breeder in this analysis.



Supplementary figure S3: Relationship between prey and predator body size (SL in mm). These data were obtained from stomach content analysis.



Supplementary figure S4: Candidate models used in phylogenetic path analysis (PPA). Each model is a causal hypothesis built on four hypotheses, proposed by previous and present studies. Note that the null model consisted only of the path connecting BS and CS.

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