

SUPPLEMENTARY MATERIAL

corresponding to:

Development of motor control and behaviour in Asian elephants in the Kabini elephant population, southern India

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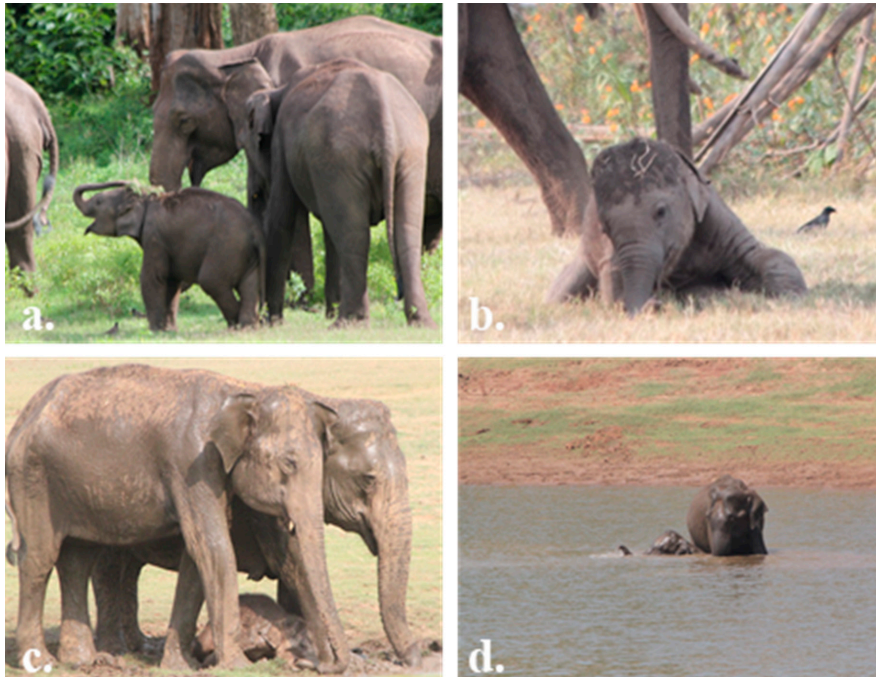
Details of various behaviours

We present here, a list of various behaviours and their categorisation, and photos of different kinds of behaviours. We recorded a total of 85 different calf activities. We classified behaviours into four behavioural classes: a) feeding, b) grooming, c) resting, and d) social interaction, play, exploration related behaviours. Four

out of these 85 activities were physiological (yawning, hiccupping, urinating, and defecating) and were not classified under any of the above-mentioned behavioural classes. Based on the level of competence of behavioural execution by a calf, the 81 behaviours were classified into four behavioural stages namely, a) preparatory calf behaviour, b) preparatory adult behaviour, c) calf-specific behaviour, and d) adult-like behaviour (see Supplementary Table 1).



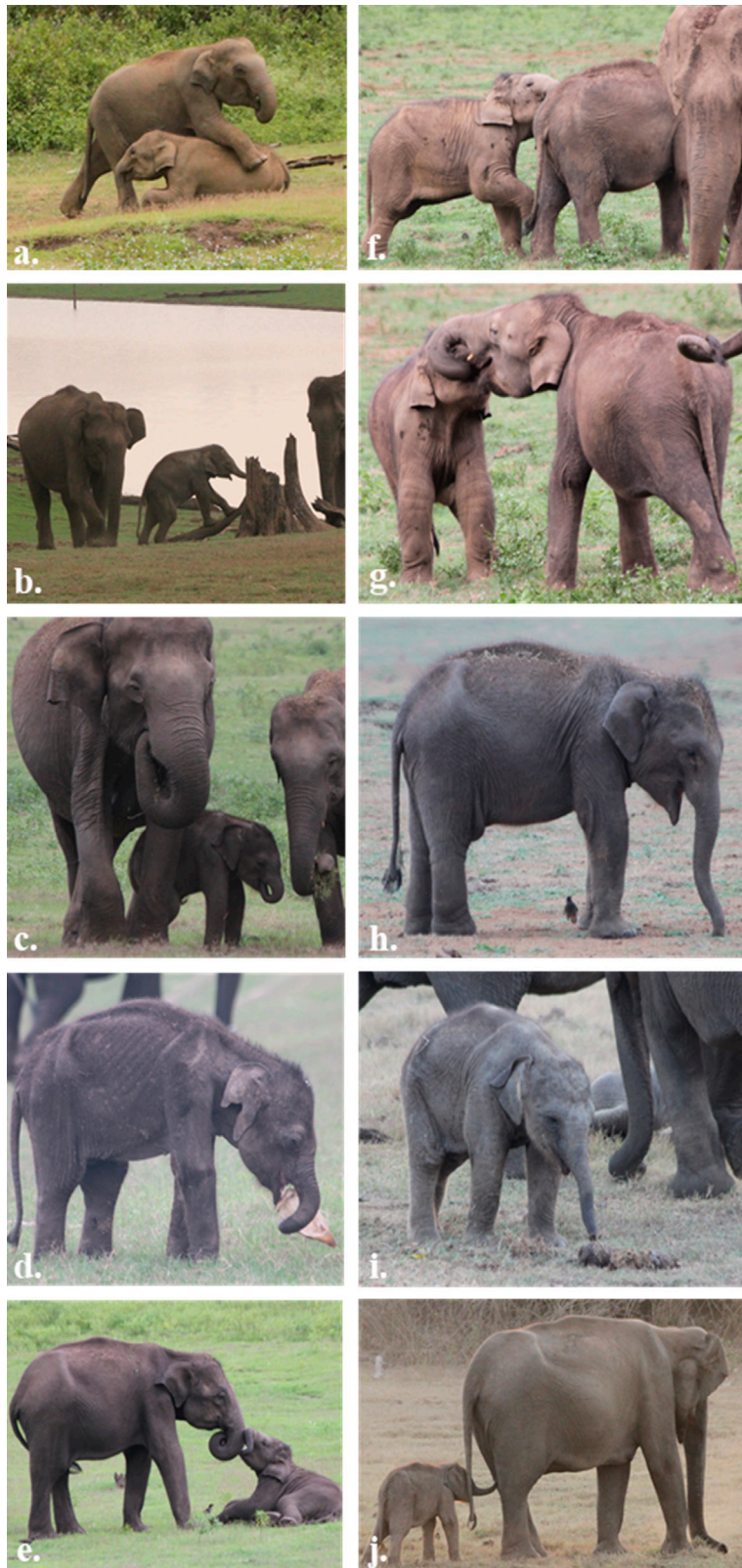
Supplementary Fig. S1. Calves and juveniles of different age classes showing feeding related behaviours belonging to four behavioural stages. a) investigate food in a conspecific's mouth and b) taking grass from a conspecific belong to preparatory adult behaviour; c) locating nipple in the correct direction and d) locating the nipple in the wrong direction belong to preparatory calf behaviour; e) coprophagy, f) sucking from a non-mother conspecific, g) holding the nipple, and h) sucking from the mother belong to calf-specific behaviours; and, i) plucking and collecting grass, j) chewing on grass, k) calf on the left drinking water using the mouth and l) drinking water using the trunk.



Supplementary Fig. S2. Adult-like grooming related behaviours shown by calves and juveniles. *a) spraying dust/grass onto oneself, b) rolling in grass, c) wallowing in mud, and d) bathing.*



Supplementary Fig. S3. Resting behaviours shown by calves can be categorized into two behavioural stages. *a) leaning on a conspecific while resting belongs to preparatory adult behaviour; b) trying to sit down, c) sitting down, and d) lying belong to adult-like behavioural expression.*



Supplementary Fig. S4. Social interactions (which includes play and explorative behaviours) of calves and juveniles belong to three behavioural stages: behaviours like a) climbing on a conspecific, b) investigating an inanimate object, c) chewing one's own trunk, d) playing with an object, and, e) trying to bite/chew any part of a conspecific, belong to the calf-specific category; f) raising one's head to place it on a conspecific belongs to preparatory adult behaviour; and, behaviours like, g) placing trunk tip in the mouth of a conspecific, h) sniffing the ground, i) smelling dung and j) checking a conspecific, belong to adult-like behaviours.

SUPPLEMENTARY TABLE 1

NAMES OF BEHAVIOURS, THEIR DESCRIPTIONS, BEHAVIOURAL CLASSES, AND BEHAVIOURAL STAGES

No.	Name of the behaviour/ activity	Behaviour code	Behaviour/activity description	Behavioural class	Behavioural stage
1	Attempt to feed	ATF	Attempt to feed on grass/browse but not successfully.	Feeding related	Preparatory adult behaviour
2	Coprophagy	COP	Eat elephant dung.	Feeding related	Calf-specific
3	Drink	DRK	Drink water using trunk to suck up water and deliver to mouth.	Feeding related	Adult-like
4	Drink with mouth	DRM	Use the mouth directly to drink from the water surface.	Feeding related	Preparatory adult behaviour
5	Feed	FED	Feed on grass/browse.	Feeding related	Adult-like
6	Walk-pluck	WSP	Sniff the ground for food or pluck grass while walking.	Feeding related	Adult-like
7	Investigate food	INV	Investigate a conspecific's food (in its mouth)/smell the grass that another individual is scraping off, but NOT take the other animal's food (which is TGC).	Feeding related	Preparatory adult behaviour
8	Push mammary gland	NPH	Push at a conspecific's (usually the mother's) mammary gland using the head.	Feeding related	Preparatory calf behaviour
9	Pull nipple	NPL	Pull at or holding a conspecific's (usually the mother's) nipple.	Feeding related	Preparatory calf behaviour
10	Search for nipple correctly	NPR	Try to locate a conspecific's (usually the mother's) nipple in the correct orientation, between the forelegs. This includes sniffing in the direction of a nipple also.	Feeding related	Preparatory calf behaviour
11	Search for nipple in the wrong direction	NPW	Try to locate a conspecific's (usually the mother's) nipple in the wrong direction, between the hind legs, or try to suck between the hind legs.	Feeding related	Preparatory calf behaviour
12	Allosuck	SUA	Suck on the mammary glands of an allomother.	Feeding related	Calf-specific
13	Suck from female	SUF	Suck on the mammary glands of a female conspecific other than the mother or allomother.	Feeding related	Calf-specific
14	Suck from mother	SUM	Suck on the mammary glands of the mother.	Feeding related	Calf-specific
15	Take grass from a conspecific	TGC	Take grass from a conspecific's scraped-off grass pile.	Feeding related	Preparatory adult behaviour
16	Take grass from a spot	TGS	Pluck grass from the same spot where a conspecific (usually the mother or allomother) is already feeding.	Feeding related	Preparatory adult behaviour
17	Alert	ALR	Stand still on alert with the ears spread out.	Social interaction, play, exploration	Adult-like
18	Avoid	AVO	Turn away/walk away/run or stop fighting with other calves and move away when being approached by the other calf's mother or allomother.	Social interaction, play, exploration	Adult-like
19	Avoid and show back	AVB	Turn away and present the back (subordinate behaviour), including spreading legs or standing still to be checked.	Social interaction, play, exploration	Adult-like
20	Chase birds	CHB	Chase after or shoo away birds by lashing out with the trunk.	Social interaction, play, exploration	Adult-like
21	Chew	CHE	Try to chew or bite any body part of a conspecific but not in dominance.	Social interaction, play, exploration	Calf-specific
22	Chew trunk	CHT	Roll trunk and place in own mouth or chew trunk or suck on the trunk tip.	Social interaction, play, exploration	Calf-specific
23	Check	CHQ	Check a conspecific but not in dominance.	Social interaction, play, exploration	Adult-like
24	Extend trunk	EXT	Extend trunk towards a conspecific.	Social interaction, play, exploration	Adult-like
25	Head butt	HBT	Head butt another calf such that the two heads meet straight on and not one over the other (this is prolonged like the trunk wrestling of adults, but the trunks are not intertwined).	Social interaction, play, exploration	Adult-like
26	Hit with head	HIT	Raise head to place it on a (usually young) conspecific's head and then bring down the head on the other individual's head with some force.	Social interaction, play, exploration	Adult-like
27	Kick conspecific	KIC	Kick a conspecific.	Social interaction, play, exploration	Adult-like
28	Kick object	KIO	Kick an inanimate object or at birds.	Social interaction, play, exploration	Adult-like
29	Kick air	KKA	Kick out in the air.	Social interaction, play, exploration	Preparatory adult behaviour
30	Lash	LSH	Lash out with the trunk towards a conspecific or heterospecific.	Social interaction, play, exploration	Adult-like
31	Place	PLC	Place the trunk on an inanimate object on the ground to smell and investigate (this excludes smelling dung). This is different from play. Here, the object is not lifted off from the ground although the object may be touched or turned.	Social interaction, play, exploration	Adult-like
32	Play climb	PCL	Climb on or roll over a conspecific in play.	Social interaction, play, exploration	Calf-specific
33	Play mount	PLM	Mount another individual from behind in play.	Social interaction, play, exploration	Preparatory adult behaviour for males
34	Play with object	PLO	Play with grass, sticks (including biting sticks), or other objects.	Social interaction, play, exploration	Calf-specific
35	Raise head in play	PRH	Raise head and try to place on another individual (even if unsuccessfully) in play and not with force.	Social interaction, play, exploration	Preparatory adult behaviour
36	Pass	PTS	Pass from one side to the other of an adult or subadult through the space between that conspecific's trunk and forelegs or under the belly.	Social interaction, play, exploration	Calf-specific
37	Play with trunk	PWT	Play with one's own trunk (all trunk motions are included in this).	Social interaction, play, exploration	Calf-specific
38	Push	PSH	Push with head against any part of the body, other than the head, of another individual.	Social interaction, play, exploration	Adult-like
39	Roar	ROR	Produce a deep prolonged laryngeal call.	Social interaction, play, exploration	Adult-like
40	Rub	RUB	Rub against a conspecific and not in dominance.	Social interaction, play, exploration	Adult-like
41	Rumble	RUM	Emit a continuous resonant laryngeal call.	Social interaction, play, exploration	Adult-like
42	Run	RUN	Run (usually in the absence of social interaction).	Social interaction, play, exploration	Adult-like
43	Shake head	SHK	Shake head when disturbed or scared.	Social interaction, play, exploration	Adult-like
44	Shove	SHO	Use the body to shove against another individual's body.	Social interaction, play, exploration	Adult-like
45	Slide	SLD	Slide off an adult's or subadult's leg to eventually lie down.	Resting	Preparatory adult behaviour
46	Smell dung	SMD	Smell dung.	Social interaction, play, exploration	Adult-like
47	Sniff conspecific	SNF	Sniff near the genitals of a conspecific but without contact, and not in dominance.	Social interaction, play, exploration	Adult-like
48	Sniff air	SNI	Sniff the air, including in the direction of a conspecific or heterospecific.	Social interaction, play, exploration	Adult-like
49	Walk-sniff	SNW	Raise trunk and sniff the air while walking.	Social interaction, play, exploration	Adult-like
50	Sniff oneself	SON	Sniff itself.	Social interaction, play, exploration	Adult-like

SUPPLEMENTARY TABLE 1 (CONTINUED)

NAMES OF BEHAVIOURS, THEIR DESCRIPTIONS, BEHAVIOURAL CLASSES, AND BEHAVIOURAL STAGES

51	Turn towards call	TDC	Turn towards the direction of a call from a conspecific.	Social interaction, play, exploration	Adult-like
52	Trumpet	TMP	Emit a loud sound (usually ascending in frequency) through the trunk.	Social interaction, play, exploration	Adult-like
53	Touch	TOU	Use trunk to touch a conspecific on its head (but not the mouth which would be TRM) or body (but not genitals which would be CHK or CHQ), and not in dominance (dominance would be TCH).	Social interaction, play, exploration	Adult-like
54	Trunk in mouth	TRM	Place trunk tip in the mouth of a conspecific.	Social interaction, play, exploration	Adult-like
55	Trip	TRP	Fall down or trip while walking.	Social interaction, play, exploration	Preparatory adult behaviour
56	Twine trunk	TTW	Entwine trunk with that of a conspecific but not in dominance.	Social interaction, play, exploration	Adult-like
57	Walk	WLK	Walk but not in response to dominance.	Social interaction, play, exploration	Adult-like
58	Pick	PIC	Try to pick up an object (other than grass).	Social interaction, play, exploration	Preparatory adult behaviour
59	Hold	HLD	Hold an object in the trunk.	Social interaction, play, exploration	Adult-like
60	Circle	CRL	Walk around in a circle (spin around).	Social interaction, play, exploration	Calf-specific
61	Shift	SFT	Shift the body or trunk without moving away from the spot such that it ends physical contact with a conspecific.	Social interaction, play, exploration	Adult-like
62	Wait	WTG	Turn towards the direction of a conspecific and wait for it to follow or stop while walking and wait for a conspecific to join.	Social interaction, play, exploration	Adult-like
63	Being pushed	BPS	Being pushed by a conspecific. This code is used when the calf is not showing any behaviour of its own but is going through the interaction initiated by a conspecific.	Social interaction, play, exploration	Adult-like
64	Hiccup	HCU	Sudden jerking movement of a calf's head and trunk (appears involuntary) accompanied by a sound.	Physio-logical	Not applicable
65	Lean	LEN	Stand or sit leaning on a conspecific.	Resting	Preparatory adult behaviour
66	Lie down	LIE	Lie down on the ground.	Resting	Adult-like
67	Sit	SIT	Sit down with hindlegs bent and the rear resting on the ground.	Resting	Adult-like
68	Squat	SQT	Bend hindlegs and prepare to sit.	Resting	Adult-like
69	Stand	STD	Stand still relaxed.	Resting	Adult-like
70	Yawn	YAW	Slow opening of the mouth, followed by the mouth being in a wide-open posture for a brief time, and subsequent quick closure of the mouth.	Physio-logical	Not applicable
71	Stretch	SRT	Stretch body usually after getting up or before lying down.	Resting	Adult-like
72	Get up	GUP	Try to get up to sitting or standing position after lying down.	Resting	Adult-like
73	Bathe	BTH	Lie down in the water.	Grooming related	Adult-like
74	Defecate	DEF	Defaecate.	Physio-logical	Not applicable
75	Extract and spray	ESP	Use trunk to extract liquid from the pharyngeal pouch and spray it on oneself.	Grooming related	Adult-like
76	Switch flies	FLY	Keep away flies using the tail or trunk.	Grooming related	Adult-like
77	Roll	ROL	Roll in the mud or on grass.	Grooming related	Adult-like
78	Scratch	SCR	Scratch itself with the trunk, leg or tail.	Grooming related	Adult-like
79	Scratch against	SIO	Scratch itself with an inanimate object or rub itself against a stump or tree.	Grooming related	Adult-like
80	Splash	SPL	Use trunk to splash water onto itself.	Grooming related	Adult-like
81	Spray	SPR	Spray dust onto itself using the trunk.	Grooming related	Adult-like
82	Splash urine	SPU	Splash a conspecific's urine onto itself.	Grooming related	Calf-specific
83	Beat tail	TLS	Beat tail against a stump or tree.	Grooming related	Adult-like
84	Touch itself	TWT	Use trunk to touch itself on any part of the body except inside mouth (which is CHE).	Grooming related	Adult-like
85	Urinate	URI	Urinate	Physio-logical	Not applicable

Details of calves/juveniles sampled for observing trunk motor control and lateral bias (see over)

The identities and age-sex categorisation of calves/juveniles sampled for observing lateralisation in trunk use are shown below.

SUPPLEMENTARY TABLE 2

THE IDENTITIES AND AGE-SEX CATEGORISATION OF CALVES/JUVENILES SAMPLED FOR OBSERVING LATERALISATION
IN TRUNK USE AND THE TIME FOR WHICH THEY WERE SCORED

S.No.	Name	Sex	Age class (months)	Duration scored (sec)
1	Althea_2015_F	Female	>12	1200
2	Emerald_2016_F	Female	6-12	899
3	Genette_2017_F	Female	<3	600
4	Georgina_2017_F	Female	<3	600
5	Hannah_2016_F	Female	<3	300
	Hannah_2016_F		3-6	300
	Hannah_2016_F		6-12	301
6	Ilaena_2016_F	Female	<3	300
	Ilaena_2016_F		3-6	300
	Ilaena_2016_F		6-12	300
7	Ilsa_2016_F	Female	<3	602
	Ilsa_2016_F		3-6	302
	Ilsa_2016_F		6-12	300
8	Ketki_2016_F	Female	<3	300
	Ketki_2016_F		3-6	300
	Ketki_2016_F		6-12	600
9	Kokila_2015_F	Female	<3	300
	Kokila_2015_F		3-6	300
	Kokila_2015_F		6-12	300
	Kokila_2015_F		>12	300
10	Leena_2017_F	Female	<3	600
	Leena_2017_F		3-6	600
11	Linda_2016_F	Female	<3	300
	Linda_2016_F		6-12	903
	Linda_2016_F		>12	300
12	Lynn_2015_F	Female	6-12	901
	Lynn_2015_F		>12	900
13	Marlene_2015_F	Female	3-6	300
	Marlene_2015_F		6-12	300
	Marlene_2015_F		>12	600
14	Salvia_2016_F	Female	<3	300
15	Suhrita_2016_F	Female	<3	303
	Suhrita_2016_F		3-6	300
16	Zarin_2015_F	Female	3-6	300
17	Alena_2017_M	Male	<3	300
	Alena_2017_M		3-6	600
18	Camila_2016_M	Male	<3	300
	Camila_2016_M		3-6	300
19	Jacintha_2015_M	Male	>12	2406
20	Kasturi_2018_M	Male	<3	600
21	Kausalya_2015_M	Male	3-6	597
	Kausalya_2015_M		6-12	904
	Kausalya_2015_M		>12	1500
22	Keerthana_2016_M	Male	6-12	600
23	Namrata_2017_M	Male	3-6	600
24	Narmada_2015_M	Male	3-6	300
	Narmada_2015_M		6-12	300
25	Sarayu_2016_M	Male	3-6	599
26	Serena_2016_M	Male	<3	300
	Serena_2016_M		3-6	300
	Serena_2016_M		>12	903
27	Suveera_2016_M	Male	<3	300
	Suveera_2016_M		3-6	300
28	Valerie_2016_M	Male	<3	602
	Valerie_2016_M		3-6	300
	Valerie_2016_M		>12	300
29	Vanessa_2015_M	Male	<3	303
	Vanessa_2015_M		3-6	600
30	Zerad_2015_M	Male	3-6	300
	Zerad_2015_M		6-12	302

Results of repeated measures ANOVAs to examine the effect of multiple sampling days of the same calves/ juveniles within the same age class

As explained in the main text, since our dataset included repeated observations on the same individuals within and across age classes, we carried out repeated measures ANOVAs on the variable examined for lateralisation (such as logit proportion of clockwise successful or unsuccessful trunk movement, logit proportion of right side trunk placement in the mouth, etc.) by the same individuals, across days but within the same age class (<3 months

old, 3-6 months, 6-12 months, and >12 months). If there was no variability across days sampled within the same age class, one sample from each individual during that age class could be used to construct the distributions of lateral bias index or strength. Results from the different repeated measures ANOVAs are given in the tables below. There was no significant effect of day of sampling (for individuals in the same age class) on the logit proportions of clockwise successful and unsuccessful trunk movements, right side mouth placement, and right side body touch, and there was only borderline significance of day when the logit proportion of straight trunk movement was considered.

SUPPLEMENTARY TABLE 3

RESULTS OF REPEATED MEASURES ANOVAS ON THE LOGIT PROPORTION OF CLOCKWISE SUCCESSFUL TRUNK MOVEMENT BY THE SAME INDIVIDUALS, ACROSS DAYS BUT WITHIN THE SAME AGE CLASS

Effect	SS	df	MS	F	P
Intercept	2.774	1	2.774	0.068	0.798
Sex	118.050	1	118.050	2.880	0.108
Error	696.763	17	40.986		
Day	2.486	1	2.486	1.343	0.262
Day x sex	0.357	1	0.357	0.193	0.666
Error	31.457	17	1.850		

Effect	SS	df	MS	F	P
Intercept	6.326	1	6.326	0.118	0.736
Age class	9.901	3	3.300	0.062	0.979
Error	804.911	15	53.661		
Day	4.931	1	4.931	3.066	0.100
Day x age class	7.689	3	2.563	1.593	0.233
Error	24.125	15	1.608		

The analysis was carried out with sex and age class as categorical factors separately for want of adequate sample size to examine them in a combined manner.

SUPPLEMENTARY TABLE 4

RESULTS OF REPEATED MEASURES ANOVAS ON THE LOGIT PROPORTION OF CLOCKWISE UNSUCCESSFUL TRUNK MOVEMENT BY THE SAME INDIVIDUALS, ACROSS DAYS BUT WITHIN THE SAME AGE CLASS

Effect	SS	df	MS	F	P
Intercept	185.131	1	185.131	5.725	0.033
Sex	70.991	1	70.991	2.195	0.162
Age class	100.515	3	33.505	1.036	0.409
Sex x Age class	124.719	3	41.573	1.286	0.321
Error	420.389	13	32.338		
Day	0.620	1	0.620	0.096	0.761
Day x sex	0.592	1	0.592	0.092	0.766
Day x age class	22.347	3	7.449	1.159	0.363
Day x sex x age class	41.034	3	13.678	2.128	0.146
Error	83.573	13	6.429		

Sex and age class were used as categorical factors.

Significant results are marked in bold.

SUPPLEMENTARY TABLE 5

RESULTS OF REPEATED MEASURES ANOVAS ON THE LOGIT PROPORTION OF STRAIGHT TRUNK MOVEMENT BY THE SAME INDIVIDUALS, ACROSS DAYS BUT WITHIN THE SAME AGE CLASS

Effect	SS	df	MS	F	P
Intercept	107.389	1	107.389	51.922	0.000
Sex	0.137	1	0.137	0.066	0.801
Age class	85.597	3	28.532	13.795	0.000
Sex x Age class	9.501	3	3.167	1.531	0.253
Error	26.888	13	2.068		
Day	7.877	1	7.877	4.919	0.045
Day x sex	4.134	1	4.134	2.582	0.132
Day x age class	1.485	3	0.495	0.309	0.818
Day x sex x age class	16.227	3	5.409	3.378	0.051
Error	20.818	13	1.601		

Sex and age class were used as categorical factors.

Significant results are marked in bold.

SUPPLEMENTARY TABLE 6

RESULTS OF REPEATED MEASURES ANOVAS ON THE LOGIT PROPORTION OF RIGHT SIDE MOUTH PLACEMENT BY THE SAME INDIVIDUALS, ACROSS DAYS BUT WITHIN THE SAME AGE CLASS

Effect	SS	df	MS	F	P
Intercept	53.590	1	53.590	2.199	0.160
Sex	81.157	1	81.157	3.331	0.089
Error	341.135	14	24.367		
Day	3.394	1	3.394	0.535	0.476
Day x sex	6.803	1	6.803	1.073	0.318
Error	88.739	14	6.339		

Effect	SS	df	MS	F	P
Intercept	34.326	1	34.326	1.062	0.322
Age class	2.113	2	1.056	0.033	0.968
Error	420.179	13	32.321		
Day	3.038	1	3.038	0.428	0.525
Day x age class	3.185	2	1.592	0.224	0.802
Error	92.357	13	7.104		

The analysis was carried out with sex and age class as categorical factors separately for want of adequate sample size to examine them in a combined manner.

SUPPLEMENTARY TABLE 7

RESULTS OF REPEATED MEASURES ANOVAS ON THE LOGIT PROPORTION OF RIGHT SIDE BODY TOUCH BY THE SAME INDIVIDUALS, ACROSS DAYS BUT WITHIN THE SAME AGE CLASS

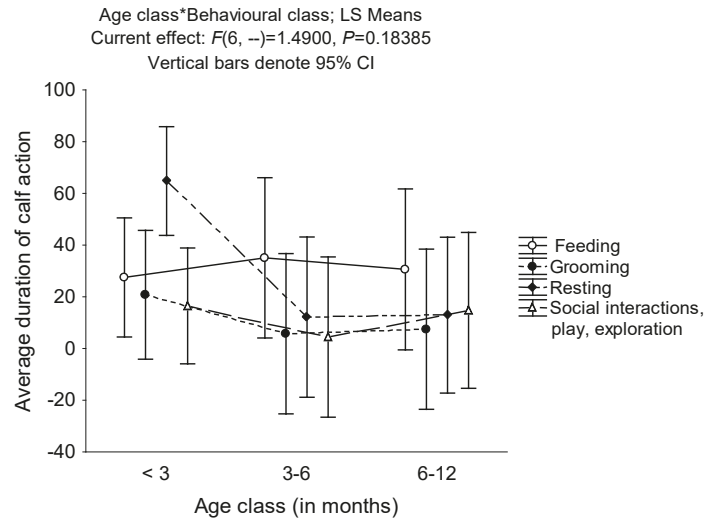
Effect	SS	df	MS	F	P
Intercept	7.663	1	7.663	1.381	0.254
Sex	14.244	1	14.244	2.567	0.126
Error	105.445	19	5.550		
Day	3.646	1	3.646	0.375	0.547
Day x sex	4.648	1	4.648	0.478	0.498
Error	184.577	19	9.715		

Effect	SS	df	MS	F	P
Intercept	4.708	1	4.708	0.715	0.409
Age class	7.761	3	2.587	0.393	0.760
Error	111.929	17	6.584		
Day	5.087	1	5.087	0.458	0.507
Day x age class	0.566	3	0.189	0.017	0.997
Error	188.659	17	11.098		

The analysis was carried out with sex and age class as categorical factors separately for want of adequate sample size to examine them in a combined manner.

Effect of age, behavioural class, and individual identity on behaviour duration

As mentioned in the main text, we carried out a GLM to examine the effects of age-class and behavioural class of calf action (fixed factors) and calf identity (random factor) on behaviour duration. We found no significant effect of age-class ($F_{2,181}=1.658, P=0.193$), behavioural class of calf action ($F_{3,181}=1.986, P=0.118$) or interaction between age class and behavioural class of calf action ($F_{6,181}=1.490, P=0.184$) on behaviour duration (see Supp. Fig. 5).



Supplementary Fig. S5. Average duration of calf action under feeding, grooming, resting, and social interaction, play, and exploration behavioural classes by calves <3 months, 3-6 months, and 6-12 months old. Error bars are 95% CI.