1 SHORT COMMUNICATION

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3 Social play in wild brown bears of varying age-sex class

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28   **Abstract**

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30   Social play behaviour is a well described phenomenon, almost ubiquitous among mammals. Despite

31   its prevalence, social play takes several forms and may vary in function across species. For solitary

32   species, the function of play outside of the family group remains unclear. Here we describe the motor

33   patterns of play among non-littermate wild brown bears *Ursus arctos* of different age-sex class. Play

34   was documented during a time of abundant food availability in three different scenarios: play among

35   non-littermate subadults, play among non-littermate cubs, and play among a 'group' of bears of

36   different age and sex class. We used a previously described behavioural ethogram to recognise play.

37   Play followed typical motor patterns and postures expressed by bears during play-fighting: relaxed

38   face, puckered-lip, ears partially flattened to crescent, wrestling, jaw gaping, play-biting, paw-

39   swatting and lunging. No vocalisations were conducted during play bouts. Older bears displayed 'self-

40   handicapping' and 'role-reversal' in the play postures they selected when playing with younger bears,

41   suggesting that tactics vary according to age class and dominance ranking. Playing likely allows for

42   the evaluation of conspecifics in a non-aggressive way during times of reduced competition and could

43   also relieve stress in complex social situations.

44

45   *Keywords*: behaviour, learning, play-fighting, social play, *Ursus arctos*.

46

47   **Introduction**

48

49   Social play is difficult to define broadly as it takes various behavioural forms and appears to vary in

50   function across species (Held & Špinka 2011). Although one universal definition may not be possible,

51   play can loosely be categorised as the adaptation of a typical stress or emergency-type response (i.e

52   attack, defend, escape, or chase) to a situation which occurs outside of its usual context (Barber 1991).

53   Play-fighting is a form of social play which usually involves non-agonistic physical contact between

54   individuals and appears, to some extent, to replicate agonistic contact-bouts, in a 'non-serious'

55   manner (Barber 1991). For example, in multiple canid species, a bow posture is used to indicate

56   playful intent in between actions such as biting and side to side head shaking, which could otherwise

57   be interpreted as acts of aggression (Bekoff 1995).

58   　　　Despite no current consensus in the literature on the ultimate cause of play fighting, functional

59   explanations usually relate to refining skills needed during combat (the practice hypothesis; Fagen

60   1981, Pellis and Pellis 1998), preparing for the unexpected (Špinka et al. 2001), self-assessment

61   (Thompson 1998), increasing physical stamina (Smith 1982), learning social skills (Bekoff 2001) and

62   expelling surplus energy (Spencer 1898 in Barber 1991). Play can be multifunctional and influenced

63   within a species by age, sex, dominance, and both social and environmental context (Brueggeman

64   1978; Tacconi and Palagi 2009).

65   　　　Assessing play behaviour can be structured in an adaptive framework; the behaviour bears

66   immediate costs but likely carries fitness benefits. Costs incurred may include time investment,

67   energetic expenditure, increased risk of predation (increased conspicuousness), direct injury, or

68   escalation into an agonistic encounter (Smith 1982). As these costs can affect future reproductive

69   success, play behaviour should have net fitness benefits or experience serious constraints (Fagen and

70   Fagen 2004). Comparing the contexts in which social play occurs at a high or low frequency may

71   indicate when it becomes too costly and therefore aid the interpretation of function (see Sharpe et al.

72   2002).

73   　　　Social play has been reported primarily for gregarious species (e.g. meerkats *Suricata suricatta*,

74   Sharpe et al 2002; lemurs *Propithecus verreauxi*, Antonacci et al 2010; macaques *Macaca* spp.,

75   Thierry et al. 2000, Ciani et al. 2012; canids *Canis* spp. Bekoff 1995), with more solitary species

76   receiving less attention. Several studies have assessed the importance of the level of gregariousness

77   between species for its relevance to social play frequency (see Pellis and Iwaniuk 2000; Ciani et al.

78   2012). As social play appears to be influenced by "socio-ecological" factors (Pellis and Iwaniuk 1999,

79   2000), solitary-living species which display a dominance hierarchical social structure could equally

80   indulge in play behaviour, due to home range overlap increasing the likelihood for individuals to

81   interact.

82   　　　Brown bears *Ursus arctos* display a dominance hierarchy social system with overlapping home

83   ranges across sexes (Stirling and Derocher 1990; McLellan and Hovey 2001) and are a species that

84   traditionally have been classed as asocial, other than during courtship or when raising young

85   (Stonorov and Stokes 1972). However, brown bears also display variation in sociality as they are

86   primarily solitary, but also form aggregations at abundant food resources, feeding within meters of

87   conspecifics (Craighead et al. 1995; Ben-David et al. 2004; M Clapham and J Kitchin pers. obs.).

88   Anecdotal observations of social play among bear cub littermates are abundant, but systematic

89   descriptions of the motor patterns and sequences of play are rare and have only sufficiently been

90   described for juvenile black bears *U. americanus* (Burghardt and Burghardt 1972; Henry and Herrero

91   1974; Pruitt 1976; Rogers 1987) and wild brown bear littermate cubs (Fagen 1981; Fagen and Fagen

92   2004). Latour (1981) also describes the motor patterns of play in adult male polar bears *U. maritimus*.

93   Most studies that report sightings of play in wild bears do not provide a systematic description of

94   behaviours and have an alternative subject focus (e.g. Herrero & Hamer 1977; Murie 1981; Stelmock

95   & Dean 1986). Here, we describe the motor patterns of social play in non-littermate wild brown bears

96   of different age-sex class. We explore exhibited behaviours under three different scenarios, not

97   systematically reported in the current literature.

98

99   **Methodology**

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101 All observations were conducted between August and October 2014 in Glendale Cove, an estuarine

102 inter-tidal zone of Knight Inlet, British Columbia, Canada (N50°41' W125°44'). Bears are protected

103 within Glendale Cove by a 15km^2 'no-hunt zone' established in 1989 by the Ministry of Environment

104 (BC provincial government). As a result of commercial bear-viewing activities at the site since 1997,

105 bears have become tolerant to being viewed and show little behavioural response to human presence,

106 unless approached too closely. Brown bears are attracted to the tidal marshes (e.g. *Carex* spp.) in the

107 south of the estuary to feed during spring, and the river mouth and Glendale Creek from August

108 onwards for the annual return of Pacific pink salmon *Oncorhynchus gorbuscha* (see Clapham et al.

109 2012 for more information on the study site). The abundance of returning fish fluctuates annually to

110 this river system (Fisheries and Ocean Canada 2014). In 2014 the drainage experienced a high return

111 of pink salmon (n = 334,021, mean over 10 years = 210,559 [estimates from Fisheries and Oceans

112   Canada 2014; Fisheries and Oceans Canada, unpublished data]). In mid-September, high tides

113   combined with high pre-spawn mortality of pink salmon, followed by high rainfall, caused carcasses

114   to be washed downstream and ultimately deposited across the marshes during ebb tide, leaving them

115   exposed and creating a feeding opportunity for bears which lasted 5-7 days.

116   Observations were conducted from either permanent viewing stands (≤7 people occupying) or

117   small aluminium skiff boats (≤7 people). Direct visual observations of bears were conducted as part

118   of ongoing research at the study site by the field team (MC and JK; see Clapham et al. 2012, 2014),

119   and by accredited (by the Commercial Bear Viewing Association of British Columbia) bear viewing

120   guides (Knight Inlet Lodge), taken during daily tours of the study site; this amounted to ~224 hours of

121   field observation for the study period. All observations were conducted during daylight hours,

122   between 0730 and 1800. However, as brown bears also forage nocturnally (Klinka and Reimchen

123   2002; Nevin and Gilbert 2005), social interactions may have occurred also outside of these viewing

124   times. Observations were recorded using a combination of field notes and photographs and/or video

125   using DSLR cameras (Canon and Nikon) with lenses ranging between 200-400mm. All observations

126   conducted adhered to ethical standards involving wild animals in accordance with the University of

127   Victoria Animal Care Committee (#2014-031(1)).

128   We used previously established definitions (indicated in italics) to recognise when social play

129   behaviour in brown bears was occurring (black bears: Henry and Herrero 1974; Pruitt 1976, brown

130   bears: Fagen 1981; Fagen and Fagen 2004, 2009). Namely, these included: a complete lack of any

131   vocalisation during direct interaction, specific facial expressions, and specific body postures during

132   contact. Similarly, we used previously described postures to recognise when an initiation to play was

133   not accepted by a potential playmate, such as signals of anxiety through scratching and low intensity

134   threat through head position and stiffening of the front legs (see Stonorov and Stokes 1972).

135   All individuals involved in play bouts (*n* = 9) have individual reference numbers [ongoing field

136   records kept at the site since 1999 (see Nevin 2003; Nevin and Gilbert 2005; Clapham et al. 2012,

137   2014)]. No interactions prior to 2014 have been observed between the cubs of female F001 and

138   female F025, or between themselves. F025 is only observed at the study site in the fall, whereas F001

139   is usually present throughout the whole non-denning period each year. The possibility that they are

140   siblings cannot be discounted. Female F001 was 13 years old and female F010 ~10 years old during

141   the study period. Subadult male M014.03 is not the offspring of F001 or F010. Cubs refers to bears

142   that were 1.5 years old during the study period (yearlings).

143

144   **Results**

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146   *Scenario 1. Play among non-littermates - independent subadults*

147   On 18 August 2014 six brown bears were observed from a viewing platform feeding at Glendale

148   spawning channel. At 0848 DST a 4-year-old subadult male (M009.01) began feeding while partially

149   submerged in water, he remained fairly stationary whilst feeding for 30 minutes. Approximately 75m

150   away upstream two 3-year-old subadult male siblings (M014.03 and M015.03) were also feeding and

151   slowly moving downstream exploiting different feeding patches. A female with two first year cubs

152   (F034) entered the pool downstream (west) at 0902. At around 0915 all bears were feeding in the pool

153   within 20m of each other; the siblings upstream in the middle of the flow, the female with cubs

154   downstream (south-west), and the subadult male roughly central to the other bears.

155   At 0918 the older subadult moved across the river and began to head upstream, past the

156   sibling males. In response to this, one of the sibling males (M015.03) moved towards the older male

157   with *partially flattened ears* and *puckered-lip face*. The older subadult paused and reciprocated the

158   approach. The younger subadult then initiated play by making a slow *lunge* towards the older male;

159   the lunge terminated with a slight gape of the jaws (*relaxed open-mouth face*, less than 30°). The

160   older subadult moved his head to avoid any contact, holding the younger male with his paws. During

161   the first minute of play-fighting, the older bear maintained a puckered-lip expression, his ears were

162   partially flattened to *partially crescent*. The younger bear's ears were maintained partially flattened

163   and his jaws were open to a maximum of 45°, as he made various lunges at the older subadult. The

164   older bear kept his face and body clear of the lunges, moving his head in anticipation of the younger

165   bear's advances (Fig. 1a).

166   At 0919 the older bear then stretched (*neck extension*) towards the other sibling (M014.03),

167   who was then feeding ~3m away, with a slight puckered expression and partially flattened ears. The

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168   sibling turned slightly towards the older subadult, but showed no other behavioural response and

169   continued to feed (Fig. 1b). The original bears then continued to play for two minutes. This bout

170   displayed increased intensity; there was less restraint showed by the older subadult and he

171   occasionally opened his mouth to a gape of 45°. Then followed a repetitive sequence of relaxed open-

172   mouth face, *pawing*, *face-pawing*, lunging, jawing, play-biting (*biting intention movements* and

173   *inhibited biting*), *rearing*, and attempts at *neck-bite-hold* (not necessarily in that order; Fig 1c-e). The

174   play bout was terminated when the older male relaxed his ears, closed his mouth, stood broadside

175   (flank facing) and moved away (Fig. 1f).

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177   *Scenario 2. Play among non-littermates – dependent cubs*

178   On 4 October 2014 at 1557 DST two family groups were observed feeding close to one another

179   (within 50m) on salmon carcasses in the estuary; F001 with two yearlings (male and female), and

180   F025 with two yearlings (male and unknown sex). Play was initiated by F001's male cub

181   approaching the cubs in the other family group. Play followed typical motor patterns and postures

182   expressed by bears when play-fighting: relaxed face, puckered-lips and ears partially flattened to

183   crescent, jaw gaping of typically no more than 20-45°, biting intention movements and inhibited

184   biting, and some face-pawing (Fig. 2a-c). Play took place while the bears were in water <1m deep and

185   also moved to land for some short bouts of wrestling and *locomotion* (chasing). Playmates were

186   interchanged between the two sets of siblings, occasionally both of F025's cubs played with F001's

187   female cub (Fig 2d). Play was occasionally paused for feeding and was not reinitiated after 1637.

188   Neither F001 nor F025 played, but frequently came in close proximity to one another's cubs (< 3m) as

189   they moved around feeding in the shallow water, to which the mother of the cubs showed no

190   behavioural response. Play was observed between the cubs of these two family groups on four

191   occasions during September/October 2014.

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193   *Scenario 3. 'Group' play among different age and sex classes*

194   On 19 September 2014 at 1140 DST we observed a female bear (F001) feeding on salmon carcasses

195   in the estuary with her two yearling cubs nearby. At 1148 a 3-year-old subadult male (MO14.03)

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196   approached from the surrounding forest-edge and walked towards the adult female. Play was initiated

197   by the subadult male as he approached with crescent ears and sniffed the lateral side of her face with

198   his face adjacent to hers. F001 responded with partially flattened ears and reciprocated by smelling

199   the lateral side of his face (Fig. 3a). She then rolled on the ground next to him and began face-pawing

200   (Fig. 3b) as the subadult male displayed biting intention movements towards her face with his jaws

201   open no more than 40°. F001 then resumed a quadrupedal stance and avoided the subadult male's

202   movements by turning her face away from his advances. The yearling cubs of F001 did not attempt to

203   approach during the play bout, but continued feeding nearby.

204   At 1150, another female with two yearlings (F010) moved west across the estuary from where

205   she had been feeding, towards F001 and M014.03; they did not appear to notice F010 moving closer

206   and continued to play. At 1152 M014.03 lead F001 over to a nearby log, which he climbed up onto

207   and used as leverage to lunge on top of F001 while exhibiting an inhibited neck bite (Fig. 3c). She

208   responded with an inhibited bite to his throat as she rolled over. The cubs of F001 then began to

209   separately move away from the approaching female with cubs (F010). F001 and M014.03 ceased

210   playing at 1155 and the subadult began to feed <5m away, while F001 remained in a siting posture

211   with *frontal alert ears* and closed mouth. At 1159 F010 approached the subadult male with crescent

212   ears, to which he responded with crescent ears and an open mouth of 20-30° (Fig. 3d). They then

213   engaged in a mixture of jaw-gaping, biting intention movements, and occasionally bipedal wrestling,

214   with crescent and partially flattened ears throughout. During this play bout, the yearling male of the

215   original female (F001) approached the playing pair and appeared to stand and observe at a distance of

216   <2m away (Fig. 3e). At this point the bears were all turned away from the observing researcher

217   making it difficult to accurately record this section of the interaction, but the playing pair did not

218   appear to engage the yearling in their play bout. F001 then moved away (~10m) to feed near her

219   female yearling; her male yearling also moved away from the playing bears.

220   F010 continued to play with the subadult, with her yearling cubs (unknown sex) now

221   observing the interaction ~10m away. At 1200 the female yearling of F001 looped behind the playing

222   bears to join the two yearlings from the other family group in observing the play bout. She displayed

223   frontal alert ears, while the other yearling's ears were relaxed (*laterad*; Fig. 3f), and moved away

224   when the playing bears came close (<3m). At 1202 as F010 began feeding, the subadult male

225   attempted to play with her two yearlings, approaching them without hesitation with crescent ears and

226   a slightly puckered-lip. However, they displayed frontal alert ear posturing, scratching, and head-low

227   postures, indicating they did not accept his advances to play. F010 continued to feed throughout this

228   interaction and showed no behavioural response to the subadult male pursuing her cubs. The subadult

229   male moved away and the play bout ended at 1202 when one cub of F010 moved directly adjacent to

230   its mother and displayed head-low and stiff-legs (low intensity threat, see Stonorov and Stokes 1972)

231   with frontal alert ears towards the male (Fig. 3g).

232

233   **Discussion**

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235   Social play in brown bears is a fairly common phenomenon within family groups, particularly

236   between sibling cubs (e.g. Fagen and Fagen 2004, 2009) and as such, is frequently observed in the

237   field by researchers and commercial bear-viewing operators (M Clapham pers. obs.). However, play

238   between non-littermates of varying age-sex class and play between the cubs of different family groups

239   has not been adequately described in the literature. By using a descriptive ethogram for social play in

240   black bears (Henry and Herrero 1974), previously supported for brown bears (Fagen and Fagen 2004,

241   2009), we were able to confirm that bears were conducting play behaviour in these scenarios.

242   We observed play behaviour between non-littermates during a time of abundant food

243   availability. High food availability is known to positively correlate with an increase in non-agonistic

244   bear interactions (Egbert and Stokes 1976) and even reduces cortisol levels in coastal brown bears

245   (Bryan et al. 2013). Fagen & Fagen (1990) also documented a higher frequency of play between

246   immature brown bears during periods of high salmon abundance and Rogers (1987) noted that non-

247   littermate black bears >7 months of age were only seen to play when near abundant food resources.

248   Likewise, in other mammals an increase in long-term food availability has been shown to more than

249   double the rate of social play under captive conditions (Sharpe et al. 2002). When food is

250   concentrated and dense, aggregations of bears form to individually exploit the resource (Stonorov and

251   Stokes 1972; Craighead et al. 1995; Ben-David et al. 2004). Bears are then faced with the dilemma of

252 increased feeding opportunity but also increased risk of injury due to close proximity to conspecifics.

253 Behavioural plasticity would therefore be a useful coping mechanism to avoid increased tension

254 during space reduction (de Waal 1989; Judge and de Waal 1993; Tacconi and Palagi 2009). Playing

255 could aid in familiarising individuals with each other in a non-aggressive way, therefore reducing

256 xenophobia (Antonacci et al. 2010).

257 Social play has been found to increase survival of brown bear dependant cubs and newly-

258 dispersed subadults (Fagen and Fagen 2004, 2009), perhaps due to reduced socially-induced stress

259 with physiological consequences (Fagen and Fagen 2009). Such immediate benefits challenge the

260 more traditional view of juvenile play, as a training exercise with benefits derived during adulthood

261 (as in Fagen 1981; Pellis and Pellis 1998; Špinka et al. 2001). Here, we documented two sets of

262 yearling cubs playing together in a nursery-like manner. Playing between non-littermates of the same

263 age may indicate a lack of social awareness, or a selection for variation in playmate ability.

264 Irrespective of the function behind selecting a playmate, juveniles likely learn social codes of conduct

265 during play bouts, termed 'social morality' by Bekoff (2001). Likewise 'eavesdropping' (see

266 McGregor 1993) on the play behaviour of older bears (scenario 3), would allow cubs to observe and

267 learn the social conduct of play without incurring the costs involved.

268 The information available to bears about their own size and dominance status during

269 development is unknown (Clapham et al. 2012). We observed play between non-littermate subadults

270 of differing age (scenario 1), and between two different adult females and a subadult male (scenario

271 3). Social play could be a method for subadult bears to self-assess physical ability during

272 development, as shown in infant sable antelopes *Hippotragus niger* (Thompson 1996). When play is

273 observed in adult mammals, it usually involves a partner of contrasting age and between them, one

274 individual will be dominant and one subordinate (Pellis and Iwaniuk 2000). Play is usually initiated

275 by the subordinate (Fagen 1981; Pellis and Iwaniuk 2000). In both scenarios, we documented 'role-

276 reversing' and 'self-handicapping' (see Bekoff and Allen 1998) by the older, presumably more

277 dominant bears. Both subadult male M009.01 (scenario 1) and adult female F001 (scenario 3) acted

278 submissively to their younger playmate by either passively turning their face or body away in

279 response to play advances without any resistance, or actively orientating their body lower to the

280   ground than the younger bear, increasing their vulnerability. Bekoff (2001) suggests that this type of

281   role reversal serves to provide a more 'level playing field' and to signal play intent by the dominant,

282   which may elongate the play bout. Play tactics appear to vary according to age class and dominance

283   ranking in brown bears.

284   Støen et al. (2005) report that brown bears are able to distinguish kin from non-kin,

285   facilitating the spatial structure of individuals. Egbert and Stokes (1976) suggest that bears learn to

286   recognise other individuals, and Craighead et al. (1995) describe individual recognition of

287   conspecifics by all members of an aggregation, and retention of such information over successive

288   seasons ("stored knowledge"). They also hypothesize that this knowledge of other individuals reduces

289   conflict and stress, and benefits the individuals which learn this information the fastest (Craighead et

290   al. 1995). Individual recognition appears to be an important factor in dominance communication at

291   aggregations and the social awareness of an individual (Craighead et al. 1995). Social play could

292   facilitate this information transfer in a non-agonistic way, which reduces risk to those involved

293   regardless of rank in the social order. Indeed, social play between adult polar bears is thought to

294   function in competitor assessment during periods of low competition, with a derived benefit when

295   competition is high (Latour 1981). This supports the theory that play-fighting functions in social

296   evaluation and manipulation (Brueggeman 1978; Pellis and Iwaniuk 2000).

297   Across the animal kingdom, there is increasing evidence that socio-ecological factors

298   influence social play. Food availability appears to dictate both the ecological and social landscape for

299   many species, including brown bears. Under complex social situations, such as dense aggregations,

300   even 'asocial' animals can demonstrate behavioural flexibility and could use tactics such as social

301   play to evaluate conspecifics and reduce xenophobia.

302

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397

Figure Captions

399   **Fig. 1** Depiction of play between non-littermate subadult male brown bears (scenario 1); **a** M015.03

400   (left) with *flattened ears* and *open-mouth face* wrestles with M009.01 (right) who displays *puckered-*

401   *lip* and *partially crescent ears*; **b** M009.01 approaching M014.03 with *neck extension*, slight

402   *puckered-lip* and *partially flattened ears*; **c** M015.03 and M009.01 *jawing* and *pawing* with *partially*

403   *flattened ears*; **d** M009.01 conducts an *inhibited bite* while *pawing*, M015.03 displays *open-mouth*

404   *face* and *partially flattened ears*; **e** M015.03 conducts a *neck-bite-hold*, M009.01 moves lower and

405   turns his body towards the other bear; **f** M009.01 ends the bout with relaxed ears (*laterad*) and closed

406   mouth. Italics indicate terms taken from the ethogram in Henry & Herrero (1974).

407   **Fig. 2** Depiction of play between non-littermate brown bear cubs (scenario 2); **a** F yearling of F001

408   (far left) with *puckered-lip face* towards M yearling of F025, M yearling of F001 (far right) wrestles

409   and attempts *neck-bite-hold* with UNK yearling of F025; **b** F yearling of F001 (right) *face-paws* M

410   yearling of F025 following *locomotion*; **c** M yearling of F001 (left) *jaws* with M yearling of F025

411   (right); **d** M yearling of F025 *lunges* on top of F yearling of F001, who displays *partially flattened*

412   *ears* and *puckered-lip*, UNK yearling of F025 observes the play (right) as F025 is feeding in the

413   background. F = female, M = male, UNK = unknown sex. Italics indicate terms taken from the

414   ethogram in Henry & Herrero (1974).

415   **Fig. 3** Depiction of a 'group' play interaction in brown bears (scenario 3); **a** F001 (front) sniffs the

416   lateral side of M014.03s face with *partially flattened ears*; **b** F001 lays on her back and *face paws*

417   M014.03; **c** M014.03 (right) *lunges* on top of F001 with *partially flattened ears* and *inhibited neck*

418   *bite*, F001 displays an *inhibited neck bite*; **d** F010 (right) approaches M014.03 with *crescent ears*,

419   M014.03 responds with *relaxed open-mouth face*; **e** M yearling of F001 (centre) approaches F010 and

420   M014.03, F010 feeds adjacent to the left, the two yearlings of F010 observe the interaction (far left)

421   and the F yearling of F010 feeds (far right); **f** F yearling of F010 (left) observes the play bout with

422   *frontal alert ears*, next to the UNK yearlings of F010 who both display relaxed ears (*laterad*); **g** UNK

423   yearling of F010 (left) displays *frontal alert ears* and head down towards M014.03. F = female, M =

424   male, UNK = unknown sex. Italics indicate terms taken from the ethogram in Henry & Herrero

425   (1974).

426   *All figures to be printed in black and white, colour online only*
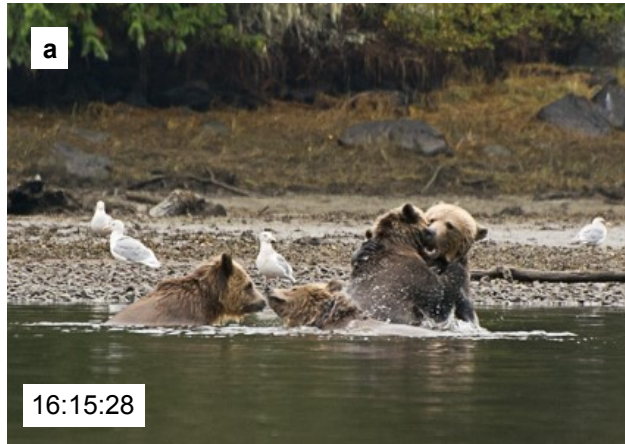
Figure 1

Figure 2

Figure 3