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### The adequacy of aging techniques in vertebrates for rapid estimation of population mortality rates from age distributions

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- 1 **Appendix S4.  $R^2$  and  $|\beta/\sigma|$  for case studies employing eight different aging techniques (telomere length, racemization, DNA methylation,**
- 2 **signal-joint T-cell Recombination Excision Circle (sjTREC), otolith ring count, otolithometry, age-length keys and skeletochronology) in**
- 3 **vertebrates.**

Indicator	Taxa	Species	Latin name	$R^2$	$ \beta/\sigma $	Reference
Telomere length	Human	Human	Homo sapiens	0.56	0.08	(Takasaki et al., 2003)
		Human	Homo sapiens	0.69	0.07	(Tsuji et al., 2002)
		Human	Homo sapiens	0.09	0.04	(Unryn et al., 2005)
		Human	Homo sapiens	0.26	0.03	(Lahnert, 2005)
		Human	Homo sapiens	0.31	0.02	(Unryn et al., 2005)
		Human	Homo sapiens	0.22	0.02	(Lahnert, 2005)
		Human	Homo sapiens	0.18	0.01	(Allsopp et al., 1992)
		Human	Homo sapiens	0.30	0.02	(Lindsey et al., 1991)
		Human	Homo sapiens	0.29	0.02	(Melk et al., 2000)
		Human	Homo sapiens	0.25	0.03	(Hastie et al., 1990)
		Human	Homo sapiens	0.40	0.03	(Furugori et al., 2000)
		Human	Homo sapiens	0.36	0.04	(Kang et al., 2002)

	Human	Homo sapiens	0.60	0.04	(Yang et al., 2001)
	Human	Homo sapiens	0.35	0.05	(Wiemann et al., 2002)
Mammal	Dog	Canis familiaris	0.02	0.04	(Nasir et al., 2001)
	Dog	Canis familiaris	0.02	0.03	(Nasir et al., 2001)
	Donkey	Equus asinus	0.17	0.05	(Argyle et al., 2003)
	Cynomolgus monkey	Macaca fascicularis	0.27	0.06	(Lee et al., 2002)
	Dog	Canis familiaris	0.47	0.42	(Yazawa et al., 2001)
	Horse	Equus caballus	0.64	0.15	(Katepalli et al., 2008)
	Japanese Black cattle	Bos taurus	0.62	0.24	(Miyashita et al., 2002)
	Sheep	Ovis aries	0.39	0.42	(Shiels et al., 1999)
Bird	Zebra finch	Taeniopygia guttata	0.54	1.60	(Hausmann and Vleck, 2002)
	Zebra finch	Taeniopygia guttata	0.82	1.52	(Hausmann and Mauck, 2008)
	Tree swallow	Tachycineta bicolor	0.34	0.36	(Hausmann et al., 2003b)
	Adelie penguin	Pygoscelis adeliae	0.55	0.30	(Hausmann et al., 2003b)
	European shag	Phalacrocorax aristotelis	0.00	0.01	(Hall et al., 2004)
	Common tern	Sterna hirundo	0.61	0.17	(Hausmann et al., 2003a)
	Leach's storm-petrel	Oceanodroma leucorhoa	0.66	0.14	(Hausmann et al., 2003b)

	Great frigatebird	<i>Fregata minor</i>	0.74	0.10	(Juola et al., 2006)
	Kakapo	<i>Strigops habroptila</i>	0.02	0.01	(Horn et al., 2011)
	Kakapo	<i>Strigops habroptila</i>	0.00	0.01	(Horn et al., 2011)
	Blue-footed booby	<i>Sula nebouxii</i>	0.00	0.00	(Foote, 2008)
	American redstart	<i>Setophaga ruticilla</i>	0.29	0.00	(Angelier et al., 2013)
	Thick-billed murre	<i>Uria lomvia</i>	0.10	0.04	(Young et al., 2013)
	Alpine swift	<i>Apus melba</i>	0.03	0.04	(Bize et al., 2009)
	Wandering albatross	<i>Diomedea exulans</i>	0.00	0.01	(Hall et al., 2004)
	Giant petrel	<i>Macronectes giganteus</i>	0.62	0.10	(Foote, 2008)
	Giant petrel	<i>Macronectes halli</i>	0.43	0.10	(Foote, 2008)
	Thick-billed murre	<i>Uria lomvia</i>	0.41	0.11	(Young et al., 2013)
	Dunlin	<i>Calidris alpina</i>	0.12	0.11	(Pauliny et al., 2006)
	Sand martin	<i>Riparia riparia</i>	0.34	0.29	(Pauliny et al., 2006)
Fish	Japanese black porgy	<i>Acanthopagrus schlegeli</i>	0.33	0.66	(Tsui, 2005)
	Medaka	<i>Oryzias latipes</i>	0.33	0.64	(Hatakeyama et al., 2008)
	Common carp	<i>Cyprinus carpio</i>	0.80	0.54	(Izzo, 2010)
	Common carp	<i>Cyprinus carpio</i>	0.73	0.51	(Izzo, 2010)

	Japanese black porgy	<i>Acanthopagrus schlegeli</i>	0.06	0.35	(Tsui, 2005)
	Common carp	<i>Cyprinus carpio</i>	0.09	0.12	(Izzo, 2010)
	Common carp	<i>Cyprinus carpio</i>	0.00	0.02	(Izzo, 2010)
	European sea bass	<i>Dicentrarchus labrax</i>	0.03	0.01	(Horn et al., 2008)
	Golden perch	<i>Macquaria ambigua</i>	0.01	0.07	(Izzo, 2010)
	Mangrove red snapper	<i>Lutjanus argentimaculatus</i>	0.15	0.34	(Tsui, 2005)
	Bluefin leatherjacket	<i>Thamnaconus degeni</i>	0.75	0.43	(Izzo, 2010)
	Mangrove red snapper	<i>Lutjanus argentimaculatus</i>	0.25	0.47	(Tsui, 2005)
	Australasian snapper	<i>Chrysophrys auratus</i>	0.80	0.50	(Izzo, 2010)
	Mangrove red snapper	<i>Lutjanus argentimaculatus</i>	0.38	0.51	(Tsui, 2005)
	Japanese black porgy	<i>Acanthopagrus schlegeli</i>	0.21	0.56	(Tsui, 2005)
	Sand flathead	<i>Platycephalus bassensis</i>	0.74	0.62	(Izzo, 2010)
	Japanese black porgy	<i>Acanthopagrus schlegeli</i>	0.18	0.81	(Tsui, 2005)
	Bluespotted goatfish	<i>Upeneichthys vlamingii</i>	0.85	1.02	(Izzo, 2010)
Reptile	Water python	<i>Liasis fuscus</i>	0.00	0.02	(Ujvari and Madsen, 2009)
	Water python	<i>Liasis fuscus</i>	0.01	0.02	(Ujvari and Madsen, 2009)
	Loggerhead turtle	<i>Caretta caretta</i>	0.09	0.02	(Hatase et al., 2008)

		Loggerhead turtle	<i>Caretta caretta</i>	0.00	0.01	(Hatase et al., 2008)
		Sand lizard	<i>Lacerta agilis</i>	0.12	0.37	(Olsson et al., 2011)
		Garter snake	<i>Thamnophis elegans</i>	0.73	0.46	(Bronikowski, 2008)
	Shark	Port Jackson shark	<i>Heterodontus portusjacksoni</i>	0.03	0.04	(Izzo, 2010)
		Port Jackson shark	<i>Heterodontus portusjacksoni</i>	0.10	0.05	(Izzo, 2010)
DNA methylation	Human	Human	<i>Homo sapiens</i>	0.82	0.15	(Lee et al., 2015)
		Human	<i>Homo sapiens</i>	0.95	0.21	(Bekaert et al., 2015)
		Human	<i>Homo sapiens</i>	0.86	0.15	(Zbiec-Piekarska et al., 2015)
		Human	<i>Homo sapiens</i>	0.69	0.13	(Bocklandt et al., 2011)
		Human	<i>Homo sapiens</i>	0.93	0.26	(Hannum et al., 2013)
		Human	<i>Homo sapiens</i>	0.06	0.02	(Christensen et al., 2009)
		Human	<i>Homo sapiens</i>	0.98	0.23	(Weidner et al., 2014)
		Human	<i>Homo sapiens</i>	0.65	0.08	(Koch and Wagner, 2011)
		Human	<i>Homo sapiens</i>	0.79	0.15	(Horvath et al., 2014)
	Mammal	Mouse	<i>Mus musculus</i>	0.93	0.27	(Maegawa et al., 2010)
		Bonobo	<i>Pan paniscus</i>	0.71	0.37	(Horvath, 2013)
		Gorilla	<i>Gorilla beringei graueri</i>	0.00	0.00	(Horvath, 2013)

			Gorilla gorilla gorilla			
sjTREC	Human	Humpback whale	Megaptera novaeangliae	0.79	0.21	(Polanowski et al., 2014)
		Human	Homo sapiens	0.67	2.38	(Ou et al., 2011)
		Human	Homo sapiens	0.65	0.18	(Cho et al., 2014)
		Human	Homo sapiens	0.76	0.76	(Ou et al., 2012)
		Human	Homo sapiens	0.77	0.76	(Qu et al., 2013)
		Human	Homo sapiens	0.84	0.10	(Zubakov et al., 2010)
		Human	Homo sapiens	0.85	0.11	(Douek et al., 1998)
Racemization	Mammal	Dog	Canis familiaris	0.00	0.00	(Ito et al., 2015)
	Human	Human	Homo sapiens	0.96	2.39	(Ohtani, 1994)
		Human	Homo sapiens	0.88	1.58	(Ohtani, 1994)
		Human	Homo sapiens	0.98	1.42	(Ohtani and Yamamoto, 1991)
		Human	Homo sapiens	0.99	0.91	(Ohtani and Yamamoto, 2010)
		Human	Homo sapiens	0.99	0.82	(Ohtani et al., 1995)
		Human	Homo sapiens	0.99	0.81	(Ohtani et al., 1995)
		Human	Homo sapiens	0.86	0.80	(Ohtani, 1994)
		Human	Homo sapiens	0.99	0.44	(Ohtani et al., 1995)

Human	Homo sapiens	0.99	0.53	(Ohtani et al., 1995)
Human	Homo sapiens	0.87	0.80	(Ohtani, 1994)
Human	Homo sapiens	0.99	0.78	(Ohtani and Yamamoto, 2010)
Human	Homo sapiens	0.98	0.61	(Ohtani et al., 1995)
Human	Homo sapiens	0.99	0.70	(Ohtani et al., 1995)
Human	Homo sapiens	0.97	0.69	(Ohtani and Yamamoto, 2010)
Human	Homo sapiens	0.99	0.65	(Ohtani and Yamamoto, 1987)
Human	Homo sapiens	0.99	0.64	(Ohtani and Yamamoto, 1992)
Human	Homo sapiens	0.98	0.63	(Ohtani and Yamamoto, 2010)
Human	Homo sapiens	0.98	0.56	(Ohtani, 1995)
Human	Homo sapiens	0.98	0.43	(Ohtani et al., 1995)
Human	Homo sapiens	0.68	0.52	(Ohtani, 1994)
Human	Homo sapiens	0.98	0.50	(Ohtani and Yamamoto, 2011)
Human	Homo sapiens	0.97	0.29	(Ohtani et al., 1995)
Human	Homo sapiens	0.98	0.44	(Fu et al., 1995)
Human	Homo sapiens	0.98	0.43	(Ohtani, 1995)
Human	Homo sapiens	0.98	0.42	(Ritz et al., 1993)



Human	Homo sapiens	0.98	0.42	(Ogino et al., 1985)
Human	Homo sapiens	0.98	0.41	(Ohtani et al., 2004)
Human	Homo sapiens	0.95	0.39	(Ohtani and Yamamoto, 2011)
Human	Homo sapiens	0.98	0.36	(Ritz et al., 1996)
Human	Homo sapiens	0.99	0.35	(Ohtani and Yamamoto, 2010)
Human	Homo sapiens	0.97	0.33	(Ohtani et al., 2002)
Human	Homo sapiens	0.98	0.32	(Ritz-Timme et al., 2003)
Human	Homo sapiens	0.97	0.29	(Ohtani, 1995)
Human	Homo sapiens	0.96	0.27	(van den Oetelaar and Hoenders, 1989)
Human	Homo sapiens	0.98	0.25	(Ritz et al., 1994)
Human	Homo sapiens	0.95	0.25	(Ohtani et al., 2002)
Human	Homo sapiens	0.95	0.25	(Rajkumari et al., 2013)
Human	Homo sapiens	0.97	0.24	(Ohtani and Yamamoto, 2011)
Human	Homo sapiens	0.95	0.24	(Ohtani et al., 2002)
Human	Homo sapiens	0.96	0.24	(Helfman and Bada, 1976)
Human	Homo sapiens	0.61	0.22	(Shapiro et al., 1991)
Human	Homo sapiens	0.92	0.22	(Ritz et al., 1994)

	Human	Homo sapiens	1.00	0.18	(Ohtani and Yamamoto, 2010)
	Human	Homo sapiens	0.92	0.17	(Ritz et al., 1990)
	Human	Homo sapiens	0.87	0.14	(Ohtani et al., 2002)
	Human	Homo sapiens	0.89	0.14	(Man et al., 1983)
	Human	Homo sapiens	0.90	0.14	(Verzija et al., 2000)
	Human	Homo sapiens	0.94	0.14	(Pfeiffer et al., 1995a)
	Human	Homo sapiens	0.73	0.12	(Ohtani et al., 1998)
	Human	Homo sapiens	0.78	0.10	(Ohtani et al., 2002)
	Human	Homo sapiens	0.83	0.09	(Masters et al., 1977)
	Human	Homo sapiens	0.81	0.09	(Maroudas et al., 1998)
	Human	Homo sapiens	0.77	0.08	(Shimoyama and Harada, 1984)
	Human	Homo sapiens	0.58	0.07	(Ohtani et al., 2002)
	Human	Homo sapiens	0.61	0.06	(Verzija et al., 2000)
	Human	Homo sapiens	0.55	0.06	(Ohtani et al., 2002)
	Human	Homo sapiens	0.76	0.06	(Fujii et al., 1999)
	Human	Homo sapiens	0.71	0.06	(Pfeiffer et al., 1995b)
Mammal	Fin whale and Narwhals	Balaenoptera physalus and Monodon	0.90	0.39	(Garde et al., 2007)

		monoceros				
		Harp seal	Pagophilus groenlandicus	0.93	0.36	(Garde et al., 2010)
	Bird	Eastern bluebird	Sialia sialis	0.45	0.98	(Hunter, 1989)
		Brown pelican	Pelecanus occidentalis	0.53	0.17	(Hunter, 1989)
		Western gull	Larus occidentalis	0.02	0.04	(Hunter, 1989)
Otolithometry, OW	Fish	Five-lined snapper	Lutjanus quinquelineatus	0.91	75.20	(Newman et al., 1996)
		Brown-striped red snapper	Lutjanus vitta	0.80	62.09	(Newman et al., 2000a)
		Brown-striped red snapper	Lutjanus vitta	0.84	53.15	(Newman et al., 2000a)
		Yellow-banded snapper	Lutjanus adetii	0.81	50.38	(Newman et al., 1996)
		Spanish flag snapper	Lutjanus carponotatus	0.68	31.61	(Newman et al., 2000a)
		Spanish flag snapper	Lutjanus carponotatus	0.68	26.67	(Newman et al., 2000a)
		Deepsea jewfish	Glaucosoma buergeri	0.91	8.01	(Newman, 2002a)
		Emperor red snapper	Lutjanus sebae	0.88	6.40	(Newman and Dunk, 2002)
		Emperor red snapper	Lutjanus sebae	0.85	6.29	(Newman and Dunk, 2002)
		Malabar blood snapper	Lutjanus malabaricus	0.92	6.24	(Newman, 2002b)
		Emperor red snapper	Lutjanus sebae	0.72	0.47	(Newman et al., 2000b)
		Crimson snapper	Lutjanus erythropterus	0.49	0.41	(Newman et al., 2000b)

Otolithometry, OL	Malabar blood snapper	Lutjanus malabaricus	0.73	0.29	(Newman et al., 2000b)
	Crimson snapper	Lutjanus erythropterus	0.86	7.85	(Newman et al., 2000b)
	Malabar blood snapper	Lutjanus malabaricus	0.90	4.32	(Newman et al., 2000b)
	Emperor red snapper	Lutjanus sebae	0.89	4.02	(Newman et al., 2000b)
	Five-lined snapper	Lutjanus quinquelineatus	0.53	1.20	(Newman et al., 1996)
	Yellow-banded snapper	Lutjanus adetii	0.35	0.95	(Newman et al., 1996)
	Brown-striped red snapper	Lutjanus vitta	0.45	0.89	(Newman et al., 2000a)
	Spanish flag snapper	Lutjanus carponotatus	0.28	0.52	(Newman et al., 2000a)
	Deepsea jewfish	Glaucosoma buergeri	0.84	0.45	(Newman, 2002a)
	Malabar blood snapper	Lutjanus malabaricus	0.71	0.35	(Newman, 2002b)
Otolithometry, OH	Emperor red snapper	Lutjanus sebae	0.34	0.34	(Newman and Dunk, 2002)
	Emperor red snapper	Lutjanus sebae	0.85	3.94	(Newman and Dunk, 2002)
	Emperor red snapper	Lutjanus sebae	0.87	3.81	(Newman and Dunk, 2002)
	Deepsea jewfish	Glaucosoma buergeri	0.91	3.56	(Newman, 2002a)
	Malabar blood snapper	Lutjanus malabaricus	0.85	2.96	(Newman, 2002b)
Otolithometry, OB	Yellow-banded snapper	Lutjanus adetii	0.46	2.00	(Newman et al., 1996)
	Brown-striped red snapper	Lutjanus vitta	0.54	1.81	(Newman et al., 2000a)

		Five-lined snapper	<i>Lutjanus quinquelineatus</i>	0.56	1.62	(Newman et al., 1996)
		Spanish flag snapper	<i>Lutjanus carponotatus</i>	0.32	1.06	(Newman et al., 2000a)
		Malabar blood snapper	<i>Lutjanus malabaricus</i>	0.73	0.69	(Newman, 2002b)
		Deepsea jewfish	<i>Glaucosoma buergeri</i>	0.77	0.66	(Newman, 2002a)
		Emperor red snapper	<i>Lutjanus sebae</i>	0.32	0.51	(Newman and Dunk, 2002)
		Emperor red snapper	<i>Lutjanus sebae</i>	0.77	0.32	(Newman et al., 2000b)
		Crimson snapper	<i>Lutjanus erythropterus</i>	0.52	0.23	(Newman et al., 2000b)
		Malabar blood snapper	<i>Lutjanus malabaricus</i>	0.75	0.19	(Newman et al., 2000b)
Otolith ring count	Fish	Murray cod	<i>Maccullochella peelii</i>	1.00	Inf	(Gooley, 1992)
		Crimson snapper	<i>Lutjanus. erythropterus</i>	0.95	3.84	(Cappo et al., 2000)
		Carpenter seabream	<i>Argyrozona argyrozona</i>	1.00	3.34	(Brouwer and Griffiths, 2004)
		Australasian snapper	<i>Pagrus auratus</i>	0.99	2.46	(Francis et al., 1992)
		John's snapper	<i>Lutjanus. johnii</i>	0.89	2.38	(Cappo et al., 2000)
		Japanese black porgy	<i>Acanthopagrus schlegeli</i>	0.73	2.27	(Tsui, 2005)
		Mangrove red snapper	<i>Lutjanus argentimaculatus</i>	0.86	1.96	(Tsui, 2005)
		Emperor red snapper	<i>Lutjanus. sebae</i>	0.60	1.27	(Cappo et al., 2000)
Age-length key	Fish	Shortnose greeneye	<i>Chlorophthalmus agassizii</i> Bonaparte	0.92	12.58	(D'Onghia et al., 2006)

Corvina reina	Cynoscion albus	0.92	8.62	(Mug-Villanueva et al., 1994)
Myers' icefish	Chionodraco myersi	0.90	7.55	(Morales-Nin et al., 2000)
Greater amberjack	Seriola dumerili	0.79	5.48	(Manooch lii and Potts, 1997)
Vermilion snapper	Rhomboplites aurorubens	0.73	5.07	(Potts et al., 1998)
Red snapper	Lutjanus campechanus	0.62	3.78	(White and Palmer, 2004)
Myers' icefish	Chionodraco myersi	0.76	2.89	(Morales-Nin et al., 2000)
Otolithes ruber	Tigertooth croaker	0.86	2.73	(Gh et al., 2012)
Cadenat's rockfish	Scorpaena loppei	0.56	1.93	(Ordines et al., 2012)
Namibian silver kob	Argyrosomus inodorus	0.63	1.85	(Kirchner and Voges, 1999)
Sharpsnout seabream	Diplodus puntazzo	0.84	1.34	(Domínguez-Seoane et al., 2006)
Sand steenbras	Lithognathus mormyrus	0.53	0.97	(Pajuelo et al., 2002)
Roughhead grenadier	Macrourus berglax	0.87	0.93	(Rodríguez-Marín et al., 2002)
Two-banded seabream	Diplodus vulgaris	0.45	0.67	(Pajuelo and Lorenzo, 2003)
Roughhead grenadier	Macrourus berglax	0.91	0.62	(Rodríguez-Marín et al., 2002)
Cadenat's rockfish	Scorpaena loppei	0.35	0.55	(Ordines et al., 2012)
West coast steenbras	Lithognathus aureti	0.87	0.36	(Holtzhausen and Kirchner, 2001)
Antarctic plunderfish	Dolloidraco longedorsalis	0.30	0.23	(Morales-Nin et al., 2000)

Skeletochronology	Mammal	Grey mouse lemur	<i>Microcebus murinus</i>	1.00	4.80	(Castanet et al., 2004)
	Reptile	Green sea turtle	<i>Chelonia mydas</i>	1.00	Inf	(Snover et al., 2011)
		Nile monitor	<i>Varanus niloticus</i>	1.00	Inf	(de Buffrénil and Castanet, 2000)
		Kemp's ridley sea turtles	<i>Lepidochelys kempii</i>	0.93	2.20	(Snover and Hohn, 2004)
		Freshwater crocodile	<i>Crocodylus johnstoni</i>	0.99	1.51	(Tucker, 1997)
		Arizona Tiger Salamander	<i>Ambystoma tigrinum nebulosum</i>	0.74	0.29	(Eden et al., 2007)
		Green turtles	<i>Chelonia mydas</i>	0.00	0.00	(Bjorndal et al., 1998)
	Amphibian	European tree frog	<i>Hyla arborea</i>	1.00	Inf	(Friedl and Klump, 1997)

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4 Note: OW, otolith weight; OL, otolith length; OH, otolith height; OB, otolith breadth. Inf, infinite  $|\beta/\sigma|$  for  $\sigma = 0$ , i.e. no error in age determination.

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