**Electronic Supplementary Materials**

**Table S1.** Summary of published work on stable isotopes of land snail shells worldwide.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Author and Year**  **of Publication** | **Journal of Publication** | **Locality / Spatial Range** | **Geologic Age Range** | **Type of Isotopic Analyses Included and Discussed** |
| Yapp, 1979 | Geochimica et Cosmochimica Acta | North America and Europe | Modern and Holocene | Entire shell δ13C and δ18O |
| Magaritz and Heller, 1980 | Palaeogeography Palaeoclimatology Palaeoecology | Negev Desert, Southern Israel | Modern and Early Holocene | Entire shell δ18O |
| Magaritz et al., 1981 | Earth and Planetary Science Letters | Israel | Modern | Entire shell δ13C and δ18O |
| Magaritz and Heller, 1983 | Chemical Geology | Israel | Modern | Entire shell and last world spire δ13C and δ18O |
| Francey, 1983 | Earth and Planetary Science Letters | Israel | Modern | Entire shell δ13C |
| Lécolle, 1985 | Chemical Geology | France, Western Europe, Northern Africa | Modern | Entire shell δ18O |
| Leone, 1985 | Palaeogeography Palaeoclimatology Palaeoecology | Jucar River, Spain | Pliocene | Entire shell δ13C and δ18O |
| Abell, 1985 | Chemical Geology | Africa | Modern | Entire shell δ18O |
| Goodfriend and Magaritz, 1987 | Earth and Planetary Science Letters | Southern Levant | Modern | Entire shell δ13C and δ18O |
| Goodfriend, 1988 | Nature | Negev Desert, Southern Israel | Middle Holocene | Shell organic δ13C |
| Goodfriend et al., 1989 | Geochimica et Cosmochimica Acta | South of Israel | Modern | Shell and snail body water δ18O |
| Goodfriend, 1990 | Quaternary Research | Negev Desert, Southern Israel | Middle Holocene | Entire shell δ13C |
| Goodfriend, 1991 | Quaternary Research | Negev Desert, Southern Israel | Holocene | Entire shell δ18O |
| Goodfriend, 1992 | Quaternary Science Reviews | An overall review | Quaternary | Entire shell and intrashell δ13C and δ18O |
| Sharpe et al., 1994 | IHLRWM Proc., ASCE and ANS | Las Vegas, Nevada | Modern | Entire shell δ18O |
| Leng et al., 1998 | The Holocene | Ethiopia, Africa | Modern | Intrashell δ13C and δ18O |
| Goodfriend, 1999 | Quaternary Science Reviews | Eastern Mediterranean | Quaternary | Entire shell δ13C and δ18O |
| Bonadonna et al., 1999 | Palaeogeography Palaeoclimatology Palaeoecology | Pampa, Argentina | Quaternary | Entire shell δ13C and δ18O |
| Leone et al., 2000 | Palaeogeography Palaeoclimatology Palaeoecology | Central Italy | Late Pliocene | Entire shell δ13C and δ18O |
| Goodfriend and Ellis, 2000 | Quaternary International | Texas | Middle-late Holocene | Entire shell and organic tissue δ13C |
| Yates et al., 2002 | Quaternary International | British Islands | Holocene | Entire shell δ13C and δ18O |
| Goodfriend and Ellis, 2002 | Geochimica et Cosmochimica Acta | North America (Southern Great Plains) | Modern | Entire shell δ13C and δ18O |
| Stott, 2002 | Earth and Planetary Science Letters | Laboratory experiment | Modern | Entire shell and organic tissue δ13C |
| Metref et al., 2003 | Earth and Planetary Science Letters | Laboratory experiment | Modern | Entire shell and organic tissue δ13C |
| Balakrishnan and Yapp, 2004 | Geochimica et Cosmochimica Acta | Empirical and theoretical model | Modern | Entire shell δ13C and δ18O |
| Zanchetta et al., 2005 | Palaeogeography Palaeoclimatology Palaeoecology | Italian Peninsula | Modern | Entire shell δ18O |
| Balakrishnan et al., 2005b | Quaternary Research | North America (from Oklahoma to New Mexico) | Modern | Entire shell δ13C and δ18O |
| Balakrishnan et al., 2005a | Quaternary Research | New Mexico, USA | Early Holocene | Entire shell δ13C and δ18O |
| Zanchetta et al., 2006 | Rivista Italiana di Paleontologia e Stratigrafia | Italy | MIS 6 and MIS 5 | Entire shell δ13C and δ18O |
| Liu et al., 2007 | Chinese Science Bulletin | Chinese Loess Plateau | Modern (field and laboratory control) | Entire shell and organic tissue δ13C |
| Colonese et al., 2007 | Palaeogeography Palaeoclimatology Palaeoecology | Southern Italy | Late Glacial | Entire shell δ13C and δ18O |
| Baldini et al., 2007 | Palaios | San Salvador, Bahamas | Modern | Entire shell and intrashell δ13C and δ18O |
| De Francesco et al., 2007 | Palaeogeography Palaeoclimatology Palaeoecology | Mendoza, Argentina | Last Glacial | Entire shell δ13C and δ18O |
| Yanes et al., 2008 | Chemical Geology | Eastern Canary Islands | Modern | Entire shell δ13C and δ18O |
| Chiba and Davison, 2009 | Paleontological Research | Ogasawara Islands, Japan | Modern | Entire shell δ13C |
| Yanes et al., 2009 | Geochimica et Cosmochimica Acta | Tenerife, Canary Islands | Modern | Entire shell δ13C and δ18O |
| Xu et al., 2010 | Radiocarbon | Chinese Loess Plateau | Modern | Entire shell δ13C |
| Colonese et al., 2010a | Journal of Quaternary Science | Southern Italy | Early-middle Holocene | Entire shell δ13C and δ18O |
| Colonese et al., 2010b | Global & Planetary Change | Southern Italy | Last Glacial-Holocene | Entire shell δ13C and δ18O |
| Kehrwald et al., 2010 | Quaternary Research | Europe (from Belgium to Serbia) | Last Glacial Maximum | Entire shell and intrashell δ18O |
| Yanes et al., 2011b | Quaternary Research | Eastern Canary Islands | Last Glacial-Holocene | Entire shell and intrashell δ13C and δ18O |
| Yanes et al., 2011a | Quaternary International | Granada, Iberian Peninsula | Early to middle Holocene | Entire shell δ13C and δ18O |
| Colonese et al., 2011 | Quaternary International | Sicily | Last Glacial-Holocene | Entire shell δ13C and δ18O |
| Zaarur et al., 2011 | Geochimica et Cosmochimica Acta | North America, Caribbean, Europe | Modern | Entire shell δ18O and clumped isotopes |
| Huang et al., 2012 | Chinese Science Bulletin | Chinese Loess Plateau | Last 75 ka | Entire shell δ13C and δ18O |
| Yanes et al., 2012 | Quaternary Research | Cantabria, Iberian Peninsula | Younger Dryas-Holocene | Entire shell and intrashell δ13C and δ18O |
| Stevens et al., 2012 | Palaeogeography Palaeoclimatology Palaeoecology | Valsequillo Basin, Central Mexico | Late Pleistocene | Entire shell δ13C and δ18O |
| Eagle et al., 2013 | Proceedings of the National Academy of Sciences | China | Last Glacial Maximum to recent | Entire shell δ18O and clumped isotopes |
| Rangarajan et al., 2013 | Chemical Geology | Bangalore, India | Modern | Intrashell δ18O |
| Colonese et al., 2013 | Quaternary Research | Argolid, Greece | Late Glacial-Holocene | Entire shell δ13C and δ18O |
| Yanes et al., 2013b | Palaeogeography Palaeoclimatology Palaeoecology | Lanzarote, Canary Islands | Last Glacial-Holocene | Entire shell δ13C and δ18O |
| Yanes et al., 2013d | Quaternary International | Jaen, Iberian Peninsula | Middle-late Holocene | Entire shell δ13C and δ18O |
| Yanes et al., 2013c | Journal of Quaternary Science | Alicante, Iberian Peninsula | Younger Dryas-Holocene | Entire shell δ13C and δ18O |
| Yanes et al., 2013a | Quaternary Research | Lanzarote, Canary Islands | Modern | Entire shell and organic tissue δ13C |
| Yanes and Romanek, 2013 | Palaeogeography Palaeoclimatology Palaeoecology | San Salvador, Bahamas | MIS 5e & Mid-Holocene | Entire shell δ13C and δ18O |
| Paul and Mauldin, 2013 | Quaternary International | Texas, North America | Late Holocene | Entire shell δ13C and δ18O |
| Colonese et al., 2014 | Palaeogeography Palaeoclimatology Palaeoecology | Aeolian Archipelago (Sicily) | Modern | Entire shell δ13C and δ18O |
| Yanes et al., 2014 | The Holocene | Ongamira, Central Argentina | Middle-late Holocene | Entire shell and intrashell δ13C and δ18O |
| Zhang et al., 2014 | Biosciences | Laboratory experiment | Modern | Entire shell and organic tissue δ13C |
| Hassan, 2015 | Chemie der Erde | El Cairo, Egypt | Modern | Entire shell δ13C and δ18O |
| Prendergast et al., 2015 | Chemical Geology | Mediterranean and North Africa | Modern | Entire shell and body fluid δ18O |
| Yanes, 2015 | Quaternary Research | Fairbanks, Alaska and SSI Bahamas | Modern | Entire shell δ13C and δ18O |
| Prendergast et al., 2016 | Quaternary Science Reviews | Libya | Pleistocene | Entire shell δ13C and δ18O |
| Wang et al., 2016 | Geochemistry Geophysics Geosystems | China | Modern | Entire shell δ18O and clumped isotopes |
| Bullard et al., 2017 | Palaeogeography Palaeoclimatology Palaeoecology | Tenerife, Canary Islands | Pleistocene | Entire shell δ18O |
| Prendergast et al., 2017 | Quaternary International | Eastern Mediterranean | Modern | Entire shell and organic tissue δ13C |
| Yanes and Fernandez-Lopez-de-Pablo, 2017 | The Holocene | Tarragona, NE Spain | Modern | Shell margin δ13C and δ18O |
| Yanes et al., 2017 | Palaeogeography Palaeoclimatology Palaeoecology | Minnesota | Modern | Entire shell δ18O |
| Ghosh et al., 2017 | Geochemistry, Geophysics, Geosystems | India | Modern and historic | Intrashell δ18O |
| Nash et al., 2018 | Quaternary Research | Illinois | Last Glacial | Entire shell δ13C and δ18O |
| Yanes et al., 2018 | Palaeogeography Palaeoclimatology Palaeoecology | Appalachian Mountains, North America | Modern | Entire shell δ18O and δ13C and organic tissue δ13C and δ15N |

**Table S2.** Oxygen stable isotope values of modern land snails from North America analyzed in this study.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample ID** | **Species** | **Family** | **Lat.**  **(°N)** | **Long.**  **(°W)** | **Alt.**  **(m a.s.l.)** | **Locality** | **Shell**  **δ18O‰**  **(PDB)** |
| MLS-1 | *Hawaiia minuscula* | Pristilomatidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -2.1 |
| MLS-2 | *Helicodiscus parallelus* | Helicodiscidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -2.1 |
| MLS-3 | *Glyphyalinia umbilicata* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -2.1 |
| MLS-4 | *Hawaiia minuscula* | Pristilomatidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.8 |
| MLS-5 | *Hawaiia minuscula* | Pristilomatidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.8 |
| MLS-6 | *Nesovitrea dalliana* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.7 |
| MLS-7 | *Nesovitrea dalliana* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.7 |
| MLS-8 | *Nesovitrea dalliana* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.5 |
| MLS-9 | *Nesovitrea dalliana* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.4 |
| MLS-10 | *Helicodiscus parallelus* | Helicodiscidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.4 |
| MLS-11 | *Hawaiia minuscula* | Pristilomatidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.2 |
| MLS-12 | *Polygyra pustula* | Polygyridae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.2 |
| MLS-13 | *Nesovitrea dalliana* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -1.1 |
| MLS-14 | *Polygyra pustula* | Polygyridae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -0.8 |
| MLS-15 | *Glyphyalinia umbilicata* | Oxychilidae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | -0.3 |
| MLS-16 | *Polygyra pustula* | Polygyridae | 30.40 | -81.40 | 1 | Fort George Island, North Florida, USA | 1.1 |
| MLS-17 | *Polygyra lithica* | Polygyridae | 36.20 | -92.30 | 183 | Norfolk Bluff, North Arkansas, USA | -3.0 |
| MLS-18 | *Pupoides albilabris* | Pupillidae | 36.20 | -92.30 | 183 | Norfolk Bluff, North Arkansas, USA | -1.8 |
| MLS-19 | *Helicina orbiculata tropica* | Helicinidae | 36.20 | -92.30 | 183 | Norfolk Bluff, North Arkansas, USA | -1.5 |
| MLS-20 | *Pupoides albilabris* | Pupillidae | 36.20 | -92.30 | 183 | Norfolk Bluff, North Arkansas, USA | -1.4 |
| MLS-21 | *Pupoides albilabris* | Pupillidae | 36.20 | -92.30 | 183 | Norfolk Bluff, North Arkansas, USA | -0.7 |
| MLS-22 | *Rabdotus dealbatus* | Orthalicidae | 36.20 | -92.30 | 183 | Norfolk Bluff, North Arkansas, USA | 0.5 |
| MLS-23 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -7.6 |
| MLS-24 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -7.2 |
| MLS-25 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -7.0 |
| MLS-26 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -6.5 |
| MLS-27 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -6.1 |
| MLS-28 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -6.0 |
| MLS-29 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -6.0 |
| MLS-30 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.9 |
| MLS-31 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.3 |
| MLS-32 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.3 |
| MLS-33 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.2 |
| MLS-34 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.2 |
| MLS-35 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.1 |
| MLS-36 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -5.0 |
| MLS-37 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -4.7 |
| MLS-38 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -4.6 |
| MLS-39 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -4.2 |
| MLS-40 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -3.5 |
| MLS-41 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -3.4 |
| MLS-42 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -3.1 |
| MLS-43 | *Succinea sp.* | Succineidae | 40.00 | -83.80 | 330 | Cedar Bog Preserve, Urbana, Central Ohio, USA | -2.9 |
| MLS-44 | *Hawaiia minuscula* | Pristilomatidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -4.8 |
| MLS-45 | *Hawaiia minuscula* | Pristilomatidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -4.6 |
| MLS-46 | *Anguispira alternata* | Discidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -4.2 |
| MLS-47 | *Hawaiia minuscula* | Pristilomatidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.9 |
| MLS-48 | *Gastrocopta contracta* | Vertiginidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.8 |
| MLS-49 | *Hendersonia occulta* | Helicinidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.7 |
| MLS-50 | *Discus catskillensis* | Discidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.6 |
| MLS-51 | *Hawaiia minuscula* | Pristilomatidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.5 |
| MLS-52 | *Gastrocopta contracta* | Vertiginidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.2 |
| MLS-53 | *Hendersonia occulta* | Helicinidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.2 |
| MLS-54 | *Hawaiia minuscula* | Pristilomatidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -3.0 |
| MLS-55 | *Gastrocopta contracta* | Vertiginidae | 43.40 | -91.80 | 350 | Heritage Farm, North East Iowa, USA | -2.6 |
| MLS-56 | *Cochlicopa lubrica* | Cochlicopidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -7.0 |
| MLS-57 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -6.5 |
| MLS-58 | *Discus catskillensis* | Discidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -6.5 |
| MLS-59 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -6.4 |
| MLS-60 | *Nesovitrea binneyana* | Oxychilidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -6.2 |
| MLS-61 | *Discus catskillensis* | Discidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -6.1 |
| MLS-62 | *Cochlicopa lubrica* | Cochlicopidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -6.1 |
| MLS-63 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -5.9 |
| MLS-64 | *Nesovitrea binneyana* | Oxychilidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -5.9 |
| MLS-65 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -5.7 |
| MLS-66 | *Nesovitrea binneyana* | Oxychilidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -5.5 |
| MLS-67 | *Nesovitrea binneyana* | Oxychilidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -5.3 |
| MLS-68 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -5.2 |
| MLS-69 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -4.7 |
| MLS-70 | *Discus catskillensis* | Discidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -4.7 |
| MLS-71 | *Vallonia gracilicosta* | Vallonidae | 48.60 | -95.60 | 357 | Randeen Ridge, northern Minnesota, USA | -4.6 |
| MLS-72 | *Vallonia gracilicosta* | Vallonidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -9.5 |
| MLS-73 | *Vallonia gracilicosta* | Vallonidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -9.4 |
| MLS-74 | *Euconulus fulvus* | Euconulidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -9.2 |
| MLS-75 | *Vallonia gracilicosta* | Vallonidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -9.0 |
| MLS-76 | *Vallonia gracilicosta* | Vallonidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.9 |
| MLS-77 | *Vallonia gracilicosta* | Vallonidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.7 |
| MLS-78 | *Discus catskillensis* | Discidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.7 |
| MLS-79 | *Vallonia gracilicosta* | Vallonidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.6 |
| MLS-80 | *Discus catskillensis* | Discidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.6 |
| MLS-81 | *Euconulus fulvus* | Euconulidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.4 |
| MLS-82 | *Nesovitrea binneyana* | Oxychilidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.4 |
| MLS-83 | *Discus catskillensis* | Discidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -8.2 |
| MLS-84 | *Discus catskillensis* | Discidae | 53.40 | -99.30 | 243 | Buffalo Lake, Central Manitoba, Canada | -7.8 |
| MLS-85 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -9.3 |
| MLS-86 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -9.2 |
| MLS-87 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.8 |
| MLS-88 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.6 |
| MLS-89 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.4 |
| MLS-90 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.4 |
| MLS-91 | *Pupilla muscorum* | Pupillidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.3 |
| MLS-92 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.3 |
| MLS-93 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.2 |
| MLS-94 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.0 |
| MLS-95 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.0 |
| MLS-96 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.0 |
| MLS-97 | *Succinea strigata* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -8.0 |
| MLS-98 | *Pupilla muscorum* | Pupillidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.9 |
| MLS-99 | *Pupilla muscorum* | Pupillidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.9 |
| MLS-100 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.6 |
| MLS-101 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.5 |
| MLS-102 | *Succinea strigata* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.5 |
| MLS-103 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.1 |
| MLS-104 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.1 |
| MLS-105 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -7.0 |
| MLS-106 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -6.9 |
| MLS-107 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -6.6 |
| MLS-108 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -6.5 |
| MLS-109 | *Oxyloma verrilli* | Succineidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -6.3 |
| MLS-110 | *Vertigo modesta modesta* | Vertiginidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -6.2 |
| MLS-111 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -6.0 |
| MLS-112 | *Euconulus fulvus* | Euconulidae | 58.70 | -94.10 | 29 | Goose Greek Road, Churchill, North Manitoba, Canada | -5.9 |

**Supplementary References**

Abell, P.I., 1985. Oxygen isotope ratios in modern African gastropod shells: a data base for paleoclimatology. Chemical Geology 58, 183–193.

Bonadonna, F.P., Leone, G., Zanchetta, G., 1999. Stable isotope analyses on the last 30 ka molluscan fauna from Pampa grassland, Bonaerense region, Argentina. Palaeogeography, Palaeoclimatology, Palaeoecology 153, 289–308.

Bullard, E.M., Yanes, Y., Miller, A.I., 2017. Compositional variability of Pleistocene land snail assemblages preserved in a cinder cone volcano from Tenerife, Canary Islands. Palaeogeography, Palaeoclimatology, Palaeoecology 471, 196–208.

Chiba, S., Davison, A., 2009. Associations between stable carbon isotope ratio and vegetation in modern and fossil land snails *Mandarina chichijimana* on Chichijima of the Ogasawara Islands. Paleontological Research 13, 151–157.

Colonese, A.C., Zanchetta, G., Dotsika, E., Drysdale, R.N., Fallick, A.E., Grifoni Cremonesi, R., Manganelli, G., 2010a. Early-middle Holocene land snail shell stable isotope record from Grotta di Latronico 3 (southern Italy). Journal of Quaternary Science 25, 1347–1359.

Colonese, A.C., Zanchetta, G., Drysdale, R.N., Fallick, A.E., Manganelli, G., Lo Vetro, D., Martini, F., Di Giuseppe, Z., 2011. Stable isotope composition of Late Pleistocene-Holocene *Eobania vermiculata* (Muller, 1774) (Pulmonata, Stylommatophora) shells from the central Mediterranean basin: data from Grotta d’Oriente (Favignana, Sicily). Quaternary International 244, 76–87.

Colonese, A.C., Zanchetta, G., Fallick, A.E., Manganelli, G., Lo Cascio, P., Hausmann, N., Baneschi, I., Regattieri, E., 2014. Oxygen and carbon isotopic composition of modern terrestrial gastropod shells from Lipari Island, Aeolian Archipelago (Sicily). Palaeogeography, Palaeoclimatology, Palaeoecology 394, 119–127.

Colonese, A.C., Zanchetta, G., Fallick, A.E., Martini, F., Manganelli, G., Drysdale, R.N., 2010b. Stable isotope composition of *Helix ligata* (Müller, 1774) from Late Pleistocene-Holocene archaeological record from Grotta della Serratura (southern Italy): palaeoclimatic implications. Global and Planetary Change 71, 249–257.

Colonese, A.C., Zanchetta, G., Fallick, A.E., Martini, F., Manganelli, G., Lo Vetro, D., 2007. Stable isotope composition of Late Glacial land snail shells from Grotta del Romito (southern Italy): palaeoclimatic implications. Palaeogeography, Palaeoclimatology, Palaeoecology 254, 550–560.

Colonese, A.C., Zanchetta, G., Perlès, C., Drysdale, R.N., Manganelli, G., Baneschi, I., Dotsika, E., Valladas, H., 2013. Deciphering late Quaternary land snail shell δ18O and δ13C from Franchthi Cave (Argolid, Greece). Quaternary Research 80, 66–75.

De Francesco, C.G., Zárate, M.A., Miquel, S.E., 2007. Late Pleistocene mollusc assemblages and inferred paleoenvironments from the Andean piedmont of Mendoza, Argentina. Palaeogeography, Palaeoclimatology, Palaeoecology 251, 461–469.

Francey, R.J., 1983. A comment on 13C/12C in land snail shells. Earth Planetary Science Letters 63, 142–143.

Ghosh, P., Rangarajan, R., Thirumalai, K., Naggs, F., 2017. Extreme Monsoon Rainfall Signatures Preserved in the Invasive Terrestrial Gastropod *Lissachatina fulica.* Geochemistry, Geophysics, Geosystems. <https://doi.org/10.1002/2017GC007041>

Goodfriend, G.A., 1988. Mid-Holocene rainfall in the Negev Desert from 13C of land snail shell organic matter. Nature 333, 757–760.

Goodfriend, G.A., 1990. Rainfall in the Negev Desert during the middle Holocene, based on 13C of organic matter in land snail shells. Quaternary Research 34, 186–197.

Goodfriend, G.A., 1991. Holocene trends in 18O in land snail shells from the Negev Desert and their implications for changes in rainfall source areas. Quaternary Research 35, 417–426.

Goodfriend, G.A., Magaritz, M., 1987. Carbon and oxygen isotope composition of shell carbonate of desert land snails. Earth Planetary Science Letters 86, 377–388.

Hassan, K.M., 2015. Stable isotopic signatures of the modern land snail *Eremina desertorum* from a low-latitude (hot) dry desert—a study from the Petrified Forest, New Cairo, Egypt. Chemie der Erde (Geochemistry) 75, 65–72.

Huang, L.P., Wu, N.Q., Gu, Z.Y., Chen, X.Y., 2012. Variability of snail growing season at the Chinese Loess Plateau during the last 75 ka. Chinese Science Bulletin 57, 1036–1045.

Leone, G., 1985. Paleoclimatology of the Casas del Rincón Villafranchian series (Spain) from stable isotope data. Palaeogeography, Palaeoclimatology, Palaeoecology 49, 61–77.

Leone, G., Bonadonna, F., Zanchetta, G., 2000. Stable isotope record in mollusca and pedogenic carbonate from Late Pliocene soils of Central Italy. Palaeogeography, Palaeoclimatology, Palaeoecology 163, 115–131.

Magaritz, M., Heller, J., 1980. A desert migration indicator—oxygen isotopic composition of land snail shells. Palaeogeography, Palaeoclimatology, Palaeoecology 32, 153–162.

Magaritz, M., Heller, J., 1983. Annual cycle of 18O/16O and 13C/12C isotope ratios in landsnail shells. Chemical Geology 41, 243–255.

Magaritz, M., Heller, J., Volokita, M., 1981. Land-air boundary environment as recorded by the 18O/16O and 13C/12C isotope ratios in the shells of land snails. Earth Planetary Science Letters 52, 101–106.

Prendergast, A.L., Stevens, R.E., Hill, E.A., Hunt, C., O’Connell, T.C., Barker, G.W., 2017. Carbon isotope signatures from land snail shells: implications for palaeovegetation reconstruction in the eastern Mediterranean. Quaternary International 432, 48–57.

Prendergast, A.L., Stevens, R.E., O’Connell, T.C., Hill, E.A., Hunt, C.O., Barker, G.W., 2016. A late Pleistocene refugium in Mediterranean North Africa? Palaeoenvironmental reconstruction from stable isotope analyses of land snail shells (Haua Fteah, Libya). Quaternary Science Reviews 139, 94–109.

Xu, B., Gu, Z., Han, J., Liu, Z., Pei, Y., Lu, Y., Wu, N., Chen,Y., 2010. Radiocarbon and stable isotope analyses of land snails from the Chinese loess plateau: environmental and chronological implications. Radiocarbon 52, 149–156.

Yanes, Y., Asta, M.P., Ibáñez, M., Alonso, M.R., Romanek, C.S., 2013a. Paleoenvironmental implications of carbon stable isotope composition of land snail tissues. Quaternary Research 80, 596–605.

Yanes, Y., García-Alix, A., Asta, M.P., Ibáñez, M., Alonso, M.R., Delgado, A., 2013b. Late Pleistocene-Holocene environmental conditions in Lanzarote (Canary Islands) inferred from calcitic and aragonitic land snail shells and bird bones. Palaeogeography, Palaeoclimatology, Palaeoecology 378, 91–102.

Yanes, Y., Gómez-Puche, M., Esquembre-Bebia, M.A., Fernández-López-De-Pablo, J., 2013c. Younger Dryas – early Holocene transition in the south-eastern Iberian Peninsula: insights from land snail shell middens. Journal of Quaternary Science 28, 777–788.

Yanes, Y., Riquelme, J.A., Cámara, J.A., Delgado, A., 2013d. Stable isotope composition of middle to late Holocene land snail shells from the Marroquíes archeological site (Jaén, southern Spain): paleoenvironmental implications. Quaternary International 302, 77–87.

Yanes, Y., Romanek, C.S., Molina, F., Cámara, J.A., Delgado, A., 2011a. Holocene paleoenvironment (~7200-4000 cal BP) of the Los Castillejos archaeological site (SE Spain) inferred from the stable isotopes of land snail shells. Quaternary International 244, 67–75.

Yanes, Y., Yapp, C.J., Ibáñez, M., Alonso, M.R., De-la-Nuez, J., Quesada, M.L., Castillo, C., Delgado, A., 2011b. Pleistocene-Holocene environmental change in the Canary Archipelago as inferred from the stable isotope composition of land snail shells. Quaternary Research 75, 658–669.

Yates, T.J.S., Spiro, B.F., Vita-Finzi, C., 2002. Stable isotope variability and the selection of terrestrial mollusc shell samples for 14C dating. Quaternary International 87, 87–100.

Zanchetta, G., Beccatini, R., Bonadonna, F.P., Bossio, A., Ciampalini, A., Colonese, A., Dall’Antonia, B., et al., 2006. Late Middle Pleistocene cool non­marine mollusc and small mammal faunas from Livorno (Italy). Rivista Italiana di Paleontolia e Stratigria 112, 135–155.

Zhang, N., Yamada, K., Suzuki, N., Yoshida, N. 2014. Factors controlling shell carbon isotopic composition of land snail *Acusta despecta sieboldiana* estimated from lab culturing experiment. Biogeosciences 11, 6555–6590.