

Deciduous dentition and dental eruption of Hyainailouroidea (Hyaenodonta, “Creodonta,”

Placentalia, Mammalia)

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In Palaeontologia Electronica

APPENDIX 1.

Character-taxon matrix used in this study, formatted for the program Mesquite

(mesquiteproject.org)

#NEXUS

[written Mon Apr 24 23:50:25 EDT 2017 by Mesquite version 3.10 (build 765) at Matthews-MacBook-Pro-3.local/192.168.0.8]

BEGIN TAXA;

DIMENSIONS NTAX=84;

TAXLABELS

Eomaia Maelestes_gobiensis Altacreodus
Akhnatenavus_leptognathus Akhnatenavus_nefertiticyon
Allopteronodon_torvidus Anasinopa_spp. Apterodon_gaudryi
Apterodon_langebadae Apterodon_macrognathus Arfia_gingerichi
Arfia_shoshoniensis Arfia_opisthotoma Boualitomus Boritia_duffaudi
Brychotherium_ephalmos Buhakia_moghraensis Cynohyaenodon_cayluxi
Cynohyaenodon_trux Dissopsalis_pyroclasticus Eoproviverra
Eurotherium_matthesi Eurotherium_theriodis Furodon Galecyon_chronius
Galecyon_mordax Galecyon_morloi Galecyon_peregrinus Gazinocyon_whitiae
Glibzegdouia Hemipsalodon Hyaenodon_horridus Hyaenodon_ErgiliynDzo
Hyaenodon_minor Hyaenodon_exiguus Hyaenodon_neimongoliensis
Hyaenailouros_sulzeri Indohyaenodon Isohyaenodon_pilgrimi Kerberos
Koholia Kyawdawia Lahimia Leakitherium_hiwegi Lesmesodon
Limnocyon_verus Leonhardtina_gracilis Masrasector_aegypticum
Masrasector_ligabuei Masrasector_nananubis Matthodon_tritens
Megistotherium Metapterodon Metasinopa_spp_ Mlanyama_sugu Morlodon
Orienspteronodon_dahkoensis Oxyaenoides_bicuspidens
Oxyaenoides_lindgreni Rukwa_Rift_hyaenodont Paratritemnodon
Paroxyaena_sp Parvagula_palulae Preregidens_langebadae
Prolimnocyon_atavus Prolimnocyon_chowi Propterodon_tongi
Propterodon_morrisi Proviverra Prototomus_minimus Prototomus_phobos
Pterodon_africanus Pterodon_dasyuroides Pterodon_phiomensis
Pyrocyon_strenuus Quasiapterodon Quercytherium_simplicidens
Quercytherium_tenebrosum Sinopa_grangeri Sinopa_jilinia Teratodon
Thinocyon Tinerhodon Tritemnodon_agilis

;

END;

BEGIN CHARACTERS;

DIMENSIONS NCHAR=148;

FORMAT DATATYPE = STANDARD GAP = - MISSING = ? SYMBOLS = " 0
1 2 3";

CHARSTATELABELS

1 dp3_paraconid_height / paraconid_indistinct_
paraconid_present_lower_than_talonid_
paraconid_present_and_taller_than_talonid_, 2 dp4_paraconid_height /
lower_than_half_protoconid_height_half_protoconid_height_or_taller, 3
dp4_metaconid_height / lower_than_half_paraconid_height_
half_paraconid_height_or_taller_, 4 dp4_talonid_basin_cusps /
Entoconid_and_hypoconid_present_ Only_hypoconid_present_, 5
dp4_talonid_length_proportion / 'More than 1/3 length of entire tooth

'less than 1/3 length of entire tooth', 6
 First_mental_foramen_position / inferior_to_p1_ inferior_to_p2_, 7
 Second_mental_foramen_position / inferior_to_p3_ inferior_to_p4_, 8
 p1_status / present_absent_, 9 p1_root_number / two_roots_
 one_root_, 10 p2_talonid_mesiodistal_length / absent_to_short_
 elongate_with_distinct_inflection_separating_postprotocristid_from_tal
 onid, 11 p2_to_p3_relative_mesiodistal_length / p2_shorter_than_p3_
 p2_as_long_or_longer_than_p3, 12 p3_inclination / 'perpendicular to
 horizontal ramus, tooth forms isosceles triangle in buccal view'
 'tooth inclines distally, preprotocristid mesially convex', 13
 p3_buccolingual_width_relative_to_mesiodistal_length /
 width_33%_of_length_ width_50%_of_length
 width_more_than_50%_of_length_, 14 p3_paraconid_morphology /
 absent_or_small_ developed_with_distinct_postparacristid_, 15
 p3_talonid_mesiodistal_length / 'short, cusp-like ' 'long, distinct
 inflection separating postprotocristid from talonid', 16
 p3_entoconid / absent_present_, 17
 p3_to_p4_relative_mesiodistal_length / p3_shorter_than_p4_
 p3_as_long_or_longer_than_p4_, 18 p4_inclination / 'perpendicular to
 horizontal ramus, tooth forms isosceles triangle in buccal view'
 'tooth inclines distally, preprotocristid mesially convex ', 19
 p4_paraconid_morphology / present_but_poorly_developed_ 'paraconid
 well-developed ' paraconid_indistinct_to_absent_, 20 p4_metaconid /
 absent_ 'present, usually weakly developed or ridge-like ', 21
 p4_entoconid / absent_present_, 22 p4_hypoconid_height / 'short,
 less than 33% of protoconid height ' 'tall, more than 33% protoconid
 height', 23 p4_talonid_basin / buccolingually_compressed_and_shallow_
 buccolingually_wide_and_deep absent_, 24
 p4_precingulid_and_postcingulid / absent_present_, 25
 p4_relative_height / mesiodistally_longer_than_height
 mesiodistally_shorter_than_height
 mesiodistal_length_and_height_subequal_, 26
 p4_height_relative_to_molars / shorter_than_all_molars_
 taller_than_m1_only_ taller_than_m2_, 27 p5_presence / present_
 absent_, 28 m1_and_m2_entoconid_morphology /
 well_developed_or_bulbous_ crestiform_with_visible_apex
 undifferentiated_entocristid_, 29 m1_and_m2_talonid_depth / deep_
 shallow_, 30 m2_entocristid_in_lingual_view / parallels_hypocristid_
 'present, stops before metaconid (lower than hypocristid)'
 weak_ridge_or_absent_, 31 m3_entocristid / parallels_hypocristid_
 'present, stops before metaconid (lower than hypocristid)'
 weak_ridge_or_absent_, 32 m1_and_m2_talonid_buccolingual_width /
 'narrow, less than 80% width of trigonid ' 'wide, greater than 80%
 trigonid', 33 m1_mesiodistal_length_relative_to_m2 /
 m1_length_subequal_or_longer_than_m2_ m1_length_less_than_m2_, 34 m1?
 m3_trigonid_height_relative_to_talonid / 'trigonid tall on all
 molars, talonid less than 50% of trigonid height ' 'trigonid low on
 all molars, talonid more than 50% of trigonid height '
 trigonid_low_on_m1_and_m2_, 35
 m3_postprotocristid_distal_trend_in_buccal_view /

slopes_mesial_to_distal_perpendicular_to_alveolus 'slopes distal to mesial (overhangs talonid) ', 36
m2_cristid_obliqua_orientation_relative_to_mesiodistal_axis / lingual_to_buccal_trend_parallel_to_mesiodistal_axis_buccal_to_lingual_trend_, 37 'm2 and m3 paraconid position relative to protoconid, angle defined relative to mesiodistal axis of mandible (Ordered)' / 'directly mesial to protoconid, 15 degrees ' 'slightly lingual paraconid, 15.1 to 45 degree angle' 'strong lingual position, 45.1 to 60 degrees ', 38 'm3 postparacristid mesial to distal trend (Ordered)' / 'steep slope to preprotocristid (?V? shaped acute angle)' 'shallow slope to preprotocristid (forms right angle with preprotocristid) ' forms_obtuse_angle_with_preprotocristid, 39
m2_and_m3_paraconid_height_relative_to_protoconid / paraconid_significantly_shorter_than_protoconid paraconid_slightly_shorter_than_protoconid paraconid_and_protoconid_subequal_in_height, 40
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m3_talonid_buccolingual_width_relative_to_m2_talonid_width / equal_

narrower_, 56 Mandible_inflection_anterior_to angular_process /
 present_ absent_, 57 Angular_process_morphology /
 distinct_process_with_medial_inflection_
 gently_curved_process_in_line_with_mandibular_corpus_
 ventral_inflection_, 58 Mandibular_condyle_position /
 superior_to_m3_alveolus_ directly_distal_to_m3_alveolus_
 inferior_to_m3_alveolus_, 59 Coronoid_process_shape / 'tall, anterior
 and posterior slopes similar ' 'tall, posterior slope concave ' 'low,
 rounded ', 60 Anterior_coronoid_angle_relative_to_horizontal_ramus /
 'near vertical, 90 to 100 degrees ' 'slight posterior inclination, 100
 to 110 degrees ' 'strong posterior inclination, greater than 110
 degrees ', 61 Masseteric_fossa_depth / 'deeply excavated with strong
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 margin, little inferior definition '
 deep_fossa_but_poorly_defined_inferior_margin, 62
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 less_than_half_metastyle_length, 63 'dP3 metacone-paracone fusion' /
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 Pterodon dasyuroides)' 'metacone fused to paracone (premetacrista sub-
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 than buccolingual width (wide) ', 67 dP3_lingual_cingulum / 'present
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 Indistinct_or_shallow_inflection_between_metacone_and_metastyle, 71
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 76 P4_parastyle / distinct_ very_reduced_to_absent_, 77
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P4_metastyle_contacts_mesial_aspect_of_M1_parastyle, 81
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'postmetacrista arcuate, no carnassial notch', 82 'M1 and M2 metastyle
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89 M1_and_M2_protocone_position_relative_to_paracone_and_metacone /
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l_ 'lateral margins trend medially, very weak ridge connects to
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Astragalar_facet_angle / oblique_orientation_to_calcaneal_neck_
parallels_calcaneal_neck ;

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Cynhyaenodon_cayluxi ?????
000001021110110100101100001102012012001111101110?0001112?????????
10001001011100?01220120211110010010012000100001000?
1001?????????????????
Cynhyaenodon_trux 200000001111101?012010(0
1)111100001000011012001111101110?0001110????????????11??10?011100?

012211101111????????????????????????????????????????
Dissopsalis_pyroclasticus ?????000100?
2000001011100211011112012123122221312210?10????000010201?
100110010111?0?112211201?12?
1????????????????????????????????????????????
Eoproviverra ?????????????????????
1001111000100000000?0000?1????????????????????01?000?
011100012?200????????????????????????????????
Eurotherium_matthesi ?????
10001111111101011011101111010011221011011012111001110????????
0110010110211011012211202011010200?011200100?01?0?0?00?000????
1001000000
Eurotherium_theriodis ?????
00011121101110101101110111010011221?110210221111????10????????
110010110211?11012211212?11?0200?011201111001?001?0?
00000111????????????
Furodon 2????0001?1????
01001100011200101010111230?2200100010?1111?02????????????0?02?
100?111221011?11?0????????????????????????
Galecyon_chronius ?????
000100110101100010021120001000010020011221001110?1011122????
1001101100000110111010021111????????????
10????????????
Galecyon_mordax ?????0001111101011(0 1)00100201?
100100001002010?220101110?10???12????????????00?0110111?1002?
11????????????????????????????????
Galecyon_morloi ?????????
010010000110001000010010011121101110?1????????0101?00?
0011011101002?11????????????????????
Galecyon_peregrinus ??????0????110101(0
1)2001000011000100001002000122100110101????????????
????????????
Gazinocyon_whitiae ?????0001100?00?
10000011011100011000100?1001?1000111101?0112????
0001101002000110111100111110?1????????112???
11000101101110
Glibzegdouia ?????????????????101?
1110010122011200?01?10?0????????????0111???0110001?1?
21????????????
Hemipsalodon ?????0001?
01100001000101021212201001100223?2202210000?111?12????
0110010011021120?010202002011102?0?100??
111010011010101????????
Hyaenodon_horridus 012110000111001011200100121212?
0102102222322203320300?10222200110011010011010011021120?012222001021?
0201001120012100100101211212011001111111000000
Hyaenodon_ErgiliynDzo ?????0001111101001200101221212?
01021022223?2203313300?1122220?????0010000011021120?012222001021?
020100112001210010010?21?02?111????1????
Hyaenodon_minor 1????0001110011011200101021212?

????????????????

Masrasector_ligabuei ?????????????0????????????????1??
10?111230??2??00?110????????????????????????????01?1?10?121?1112?
2????????????????????????????????????????????????????????

Masrasector_nananubis
21000000001010101000001100110111110011123022100001110?
0010001010101101??1000000101110101121112120211011?011?010111?0011?01?
100?00000????????????????

Matthodon_tritens ?????
10011012111011010100110121100220212212122011101101122????????????
10????????????????????????????????????01????????????011?
1????????????????

Megistotherium ?????????????????0200101211212?
01002111233?22033?1?00????????????????11?10?0?00?1?????1????????1??
200?1100111201000101011?21?1?????010011????

Metapterodon ?????111?00020000010100001121??
0100111023322212321300?1????1????????????00111110021120?
11110200211211??0????????????????????????????????????

Metasinopa_spp_ ?
100000010101000101010110111010110011112302222120111101?1111011110?
11?????????011001001212121?
10????????????????????????????????????????????????????

Mlanyama_sugu ?????0?0011120001?????????121120?
002121?33?
2202310110????????????????????????????????????????????????????
????????????????????????????????????

Morlodon ?????0000000110000001000011000?
11000100?00000?1?00?00????????????????00?
01001011101011110220202000????????????????????????????????
???

Orienspteron_dahkoensis ?????
00011001010012011102111011110011102232220220111101????1????????????
0001000021?0?111?2002?
11????????????????????????????????????????????????????

Oxyaenoides_bicuspidens ?????
000110111100100110001121110102102021322212211010?1122120????????????
0?????020110?0122012020100????????????????????????0011?1????
0?????0100

Oxyaenoides_lindgreni ?????0000??10110010011000?
1210000021010213?221221111001????2????????????????02?????122012?
1?11????????????????????????????????????

Rukwa_Rift_hyaenodont ?????????????????????????????????
????????????????????011101?
0????????????????????????????????????????????????????????
??????????

Paratritemnodon ?????0001?
001000110010010111000110111012302?210101111101???11????????00?
10100011101001111101201101????????????????????????????????
???

[illegible]

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Pyrocyon_strenuus      ?????
000010020100000000010111001101010011001111100010?100???12??????????0?
00001011011101011121100201100????????????????????????????????????
??????
Quasiapterodon         ?????
00001101010101011101120111000110020222111011111011?11??????????
10001100001001101010101111001????????????????????????????????????
??????
Quercytherium_simplicidens  ?????000001?
201010001011021000010000120230?111101111111???10????????????
00100000200011112101202?10?0021000112020000011100?
10????????????????????????
Quercytherium_tenebrosum   ?????
0000010200010201010221000010020121220?(1 2)211201110?1????
10????????????
00010000020001111210120101111????????????????????????????????????
??????
Sinopa_grangeri         ?????
0001100101000100001111100011000110220000211011110100001????????
001001(0 1)001011101101111011102100110110012101000011101?
000012110111100?1?1???000
Sinopa_jilinia          ??????????1001?100????????
11000110011102200002000111111001001????????????????????????????
????????????????????????????????????????????????????????
Teratodon               ??????000001020001?101010??
1101111100111230?2200001110??1???21????????????210100010111?
1001101012102000????????????????????????????????????????
Thinocyon               ??????0000010100000000001001100?
110?11?0??0?0?30??1?10??020002????????????1000101101000110121111110212?
02?00001210?10100100010?000100100000?001000000
Tinerhodon              ??????????00100001111100022100001?
010200??000010000000?0????????????????????
0????????????????????????????????????????????????????????
Tritemnodon_agilis      ?????
000110100100110000111121001101110021110212201110?0110112????????
001001010102111100111120020110011?0?0?11?11?101??01?100?
001001000010000??0000

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;

END;
begin mrbayes;
    set autoclose = yes nowarn = yes;
    lset nst = 6 rates = invgamma;
    unlink statefreq = ( all ) revmat = ( all ) shape = ( all )
pinvar = ( all );
    ctype ordered : 37 38 42 43 44 45 46 47 48 49 51 68 82 93 94
100 102;
    prset applyto = ( all ) ratepr = variable;
    mcmc ngen = 10000000 relburnin = yes burninfrac = 0.25

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printfreq = 1000 samplefreq = 1000 nchains = 4 savebrlens = yes;
    mcmc;
    sump;
    sumt contype = allcompat;

END;
BEGIN ASSUMPTIONS;
    TYPESET * UNTITLED = unord: 1 - 36 39 - 41 52 - 67 69 -
81 83 - 92 95 - 99 101 103 - 148, ord: 37 - 38 42 - 51 68 82 93
- 94 100 102;

END;

BEGIN MESQUITECHARMODELS;
    ProbModelSet * UNTITLED = 'Mk1 (est.)': 1 - 148;
END;

Begin MESQUITE;
    MESQUITESCRIPTVERSION 2;
    TITLE AUTO;
    tell ProjectCoordinator;
    timeSaved 1493092225647;
    getEmployee #mesquite.minimal.ManageTaxa.ManageTaxa;
    tell It;
        setID 0 8054226866882262511;
    endTell;
    getEmployee
#mesquite.charMatrices.ManageCharacters.ManageCharacters;
    tell It;
        setID 0 1707752251427169162;
        mqVersion 310;
        checksumv 0 3 1779091596 null getNumChars
148 numChars 148 getNumTaxa 84 numTaxa 84 short true bits 15
states 15 sumSquaresStatesOnly 31706.0 sumSquares 31706.0
longCompressibleToShort false usingShortMatrix true NumFiles 1
NumMatrices 1;
        mqVersion;
    endTell;
    getWindow;
    tell It;
        suppress;
        setResourcesState false false 100;
        setPopoutState 300;
        setExplanationSize 0;
        setAnnotationSize 0;
        setFontIncAnnot 0;
        setFontIncExp 0;
        setSize 1199 687;
        setLocation 0 23;
        setFont SanSerif;

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        setFontSize 10;
        getToolPalette;
        tell It;
        endTell;
        desuppress;
    endTell;
    getEmployee
#mesquite.charMatrices.BasicDataWindowCoord.BasicDataWindowCoord;
    tell It;
        showDataWindow #1707752251427169162
#mesquite.charMatrices.BasicDataWindowMaker.BasicDataWindowMaker;
    tell It;
        getWindow;
        tell It;
            setExplanationSize 30;
            setAnnotationSize 20;
            setFontIncAnnot 0;
            setFontIncExp 0;
            setSize 1099 615;
            setLocation 0 23;
            setFont SanSerif;
            setFontSize 10;
            getToolPalette;
            tell It;
                setTool
mesquite.charMatrices.BasicDataWindowMaker.BasicDataWindow.ibeam;
            endTell;
            setActive;
            setTool
mesquite.charMatrices.BasicDataWindowMaker.BasicDataWindow.ibeam;
            colorCells
#mesquite.charMatrices.NoColor.NoColor;
            colorRowNames
#mesquite.charMatrices.TaxonGroupColor.TaxonGroupColor;
            colorColumnNames
#mesquite.charMatrices.CharGroupColor.CharGroupColor;
            colorText
#mesquite.charMatrices.NoColor.NoColor;
            setBackground White;
            toggleShowNames off;
            toggleShowTaxonNames on;
            toggleTight off;
            toggleThinRows off;
            toggleShowChanges on;
            toggleSeparateLines off;
            toggleShowStates on;
            toggleAutoWCharNames on;
            toggleAutoTaxonNames off;
            toggleShowDefaultCharNames
off;

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toggleConstrainCW on;
toggleBirdsEye off;
toggleShowPaleGrid off;
toggleShowPaleCellColors
off;

toggleShowPaleExcluded off;
togglePaleInapplicable on;
toggleShowBoldCellText off;
toggleAllowAutosize on;
toggleColorsPanel off;
toggleDiagonal on;
setDiagonalHeight 80;
toggleLinkedScrolling on;
toggleScrollLinkedTables
off;

endTell;
showWindow;
getWindow;
tell It;
    forceAutosize;
endTell;
getEmployee
#mesquite.charMatrices.AlterData.AlterData;
tell It;
    toggleBySubmenus off;
endTell;
getEmployee
#mesquite.charMatrices.ColorByState.ColorByState;
tell It;
    setStateLimit 9;
    toggleUniformMaximum on;
endTell;
getEmployee
#mesquite.charMatrices.ColorCells.ColorCells;
tell It;
    setColor Red;
    removeColor off;
endTell;
getEmployee
#mesquite.categ.StateNamesEditor.StateNamesEditor;
tell It;
    makeWindow;
    tell It;
        getTable;
        tell It;

rowNamesWidth 265;

endTell;
setExplanationSize
30;

```

```

20;
setAnnotationSize
setFontIncAnnot 0;
setFontIncExp 0;
setSize 1099 615;
setLocation 0 23;
setFont SanSerif;
setFontSize 10;
getToolPalette;
tell It;
setTool
mesquite.categ.StateNamesEditor.StateNamesWindow.ibeam;
endTell;
rowsAreCharacters
on;
toggleConstrainChar
on;
toggleConstrainCharNum 3;
togglePanel off;
toggleSummaryPanel
off;
endTell;
showWindow;
endTell;
getEmployee
#mesquite.categ.StateNamesStrip.StateNamesStrip;
tell It;
showStrip off;
endTell;
getEmployee
#mesquite.charMatrices.AnnotPanel.AnnotPanel;
tell It;
togglePanel off;
endTell;
getEmployee
#mesquite.charMatrices.CharReferenceStrip.CharReferenceStrip;
tell It;
showStrip off;
endTell;
getEmployee
#mesquite.charMatrices.QuickKeySelector.QuickKeySelector;
tell It;
autotabOff;
endTell;
getEmployee
#mesquite.charMatrices.SelSummaryStrip.SelSummaryStrip;
tell It;
showStrip off;
endTell;

```

```

getEmployee
#mesquite.categ.SmallStateNamesEditor.SmallStateNamesEditor;
tell It;
    panelOpen true;
endTell;
endTell;
endTell;
getEmployee
#mesquite.charMatrices.ManageCharacters.ManageCharacters;
tell It;
    showCharacters #1707752251427169162
#mesquite.lists.CharacterList.CharacterList;
tell It;
    setData 0;
    getWindow;
    tell It;
        newAssistant
#mesquite.lists.DefaultCharOrder.DefaultCharOrder;
        newAssistant
#mesquite.lists.CharListInclusion.CharListInclusion;
        newAssistant
#mesquite.lists.CharListPartition.CharListPartition;
        newAssistant
#mesquite.parsimony.CharListParsModels.CharListParsModels;
        setExplanationSize 30;
        setAnnotationSize 20;
        setFontIncAnnot 0;
        setFontIncExp 0;
        setSize 1099 615;
        setLocation 0 23;
        setFont SanSerif;
        setFontSize 10;
        getToolPalette;
        tell It;
        endTell;
    endTell;
    showWindow;
    getEmployee
#mesquite.lists.CharListAnnotPanel.CharListAnnotPanel;
tell It;
    togglePanel off;
endTell;
endTell;
endTell;
endTell;
end;

```