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The King's Arms
18 West Street
Chipping Norton
Oxfordshire

Tree-ring Analysis of Oak Timbers

Martin Bridge and Cathy Tyers

Discovery, Innovation and Science in the Historic Environment

Research Report Series no. 208-2020

Front Cover: The King's Arms, 18 West Street, Chipping Norton, Oxfordshire. © Historic England. Photograph by Martin Bridge

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NGR: SP 31314 26928

ISSN 2059-4453 (Online)

SUMMARY
Four areas of the property were investigated: beams in the ground-floor bar area of the main range, the roof of the main range, the roof of the rear east-west range, and an annexe to the east. Many timbers contained too few rings for further analysis, and several others showed abrupt growth rate changes. None of the timbers sampled could be securely dated.

CONTRIBUTORS
Martin Bridge and Cathy Tyers

ACKNOWLEDGEMENTS
We are very grateful to the owners who were very helpful in allowing sampling and investigation throughout the complex. This site was one of several investigated at as part of the Early Fabric in Historic Towns: Chipping Norton project, and we thank Rebecca Lane for managing the project on behalf of Historic England. Particular thanks go to Victoria Hubbard for her extensive input on coordinating the project in the town and her friendly encouragement, and to other members of the Chipping Norton Buildings Record and Oxfordshire Buildings Record. We are also grateful to Shahina Farid for commissioning the work and her input into the production of this report.

ARCHIVE LOCATION
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DATE OF INVESTIGATION
2015

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CONTENTS

INTRODUCTION

The Early Fabric in Historic Towns: Voluntary Group Projects, funded by Historic England, have been developed in the recognition and acknowledgement of the excellent work being undertaken by local vernacular groups in the study of local architectural trends and fabrics. The intention of these projects is to encourage this type of study through the provision of support and facilitate training of more people in building analysis and recording. The local projects were coordinated by Rebecca Lane (Historic England South West Region: Architectural Investigation).

Early Fabric in Chipping Norton Project

Whilst Chipping Norton features in a study on historic towns in Oxfordshire (Rodwell 1975), and some buildings have been recorded and published in detail (eg Simons and Phimester 2005), no systematic research had been undertaken on the buildings of the town before this project.

The project examined vernacular historic buildings in the centre of Chipping Norton, aiming to improve understanding of the morphology and development of the historic town plan and to understand this within the framework of economic and social change. It aimed to identify early plan forms and to understand the dates of the introduction of vernacular architectural details (eg in materials, carpentry, fenestration, and decorative features), thus mapping the survival of early (pre-1900) fabric and revealing the architectural evolution of the town's buildings.

Initially, 21 properties were identified that were thought to be key to understanding the town's architectural development for a programme of comprehensive investigation. These properties were assessed for their suitability for dendrochronology and 12 that contained oak timber considered suitable for analysis were initially sampled and analysed. Oak timbers from seven of these buildings could be dated by ring-width dendrochronology, whilst radiocarbon wiggle-matching was undertaken for one of the buildings where the ring-width dendrochronology had produced an undated site master chronology.

The results of the project are presented by Rosen and Cliffe (2017). The reports produced on the historic buildings recorded as part of this project by the Chipping Norton Buildings Record/Oxfordshire Buildings Record (OBR) will be deposited in the Oxfordshire Historic Environment Record.

The King's Arms

The property lies on the junction of two major roads in the town, West Street and Burford Road (Fig 1). It is listed at grade II (LEN 1052598) as a seventeenth-century building, re-fronted in the eighteenth century. As an important early building in the town, it was a natural candidate for dendrochronological investigation as part of the *Early Fabric in Historic Towns: Chipping Norton* project. It was hoped that any results might give additional evidence on the development of the building and hence enhance understanding of its part in the early development of this historic town.

The main range parallel to West Street has a roof structure of four bays plus an additional area over the oddly shaped corner section at the south end, with two tiers of inset butt purlins, some of which are thought to be re-used timbers. To the rear, there is a range perpendicular to the front range, with a single central truss and two tiers of purlins. A large annexe to the rear of the main body of the hotel has large timbers with two readily accessible trusses and their associated purlins.

METHODOLOGY

Fieldwork for the present study was carried out in October 2015, following an initial assessment of the potential for dating a few weeks beforehand, and consultation with those involved in the project. In the initial assessment, accessible oak timbers with more than 50 rings and where possible traces of sapwood were sought, although slightly shorter sequences are sometimes sampled if little other material is available. Those timbers judged to be potentially useful were cored using a 16mm diameter auger attached to an electric drill. The cores were labelled, and stored for subsequent analysis.

The cores were polished on a belt sander using 80–400 grit abrasive paper to allow the ring boundaries to be clearly distinguished. The samples had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). Cross-matching was attempted by a process of qualified statistical comparison by computer, supported by visual checks. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted on the computer monitor to allow visual comparisons to be made between sequences. This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one sample or site master against other samples or chronologies, *t*-values over 3.5 are considered significant, although in reality it is common to find demonstrably spurious *t*-values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists prefer to see some *t*-values in the range of 5, 6, and higher, and for these to be well replicated from different, independent chronologies with both local and regional chronologies well represented, except where imported timbers are identified. Where two individual samples match together with a *t*-value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have originated from the same parent tree. Same-tree matches can also be identified through the external characteristics of the timber itself, such as knots and shake patterns. Lower *t*-values, however, do not preclude same tree derivation.

Ascribing felling dates and date ranges

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. Depending on the completeness of the final ring (ie if it has only the spring vessels or earlywood formed, or the latewood or summer growth) a precise felling date and season can be given. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date range can be given for each sample. The number of sapwood rings can be estimated by using an empirically derived sapwood estimate with a given confidence limit. If no sapwood or heartwood/sapwood boundary survives then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* (*tpq*) or felled-after date.

A review of the geographical distribution of dated sapwood data from historic timbers has shown that a sapwood estimate relevant to the region of origin should be used in interpretation, which in this area is 9–41 rings (Miles 1997). It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure or object under study.

RESULTS AND DISCUSSION

Details of the samples taken are given in Table 1, and the approximate positions of the sampled timbers are illustrated on Figures 2 and 3. A number of the samples did not have enough rings for reliable dating purposes. The beams on the ground floor in the bar area were heavily painted and could not be readily assessed. Each had a different moulding profile and were therefore considered possibly to be of different dates, but on sampling each was found to have fewer than 35 rings. Also in this main range the timbers in the roof produced a single sample from a large principal rafter with just 45 rings, and two others with fewer than 35 rings which were not measured. In the rear east-west range roof the samples had more rings, and all were measured, even though one had only 38 rings. The annexe to the rear of the main building yielded seven samples of which two had too few rings to be useful for further analysis. The ring-width data for the measured samples are given in the Appendix.

Comparisons between the samples showed a number of pairs that matched each other. In the rear east–west roof, the ring-width series from sample 21 matched that of sample 23 (t = 7.8 with 35 years overlap), and the series from sample 22 matched that from sample 24 (t = 5.5 with 48 years overlap). Each of these pairs were combined for further analysis. From the annexe, sample 30 matched sample 35 (t = 5.5 with 34 years overlap). This short overlap meant the match was regarded with caution, but a new combined ring-width series was made and compared with the database of oak reference chronologies. There were other potential cross-matches identified between samples from the different areas of the building but these were again short and thus considered inconclusive and potentially simply an artefact of the abrupt growth changes seen in a number of the

samples. These abrupt growth changes (Figures 4 and 5), combined with the relative short ring series obtained, are likely to reflect highly localised environmental growth conditions at the expense of the more general climatic signal required for successful dating. Hence it was relatively unsurprising that comparison with a wide geographical range of reference chronologies, in addition to those produced from other buildings in Chipping Norton during this project, produced no reliable dating for any of the new combined series or the other individual series.

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TABLES

Table 1: Details of the samples taken from the King's Arms, Chipping Norton.

Sample number	Timber and position	No of rings	Mean ring width (mm)	Sapwood rings	Mean sensitivity
Main Front range					
cnKNG01	Beam at east end of bar	<35	NM	h/s	-
cnKNG02	Beam in mid-bar area	<35	NM	-	-
cnKNG03	West principal rafter, south end truss	45	2.42	h/s	0.23
cnKNG04	Collar, south end truss	<35	NM	h/s	-
cnKNG05	West principal rafter, north end truss	<35	NM	h/s	-
Rear East-West Range					
cnKNG20	South-west upper purlin	107	0.83	32C	0.20
cnKNG21	North-east upper purlin	53	1.81	17+5NM	0.41
cnKNG22	North principal rafter, central truss	78	1.48	28C	0.24
cnKNG23	North-east lower purlin	38	1.77	21¼C	0.28
cnKNG24	South principal rafter, central truss	48	1.35	25C	0.26
cnKNG25	South-west lower purlin	110	1.22	30C	0.26
Annexe					
cnKNG30	Central tiebeam	57	2.74	17?C	0.26
cnKNG31	South principal rafter, central truss	<35	NM	h/s	-
cnKNG32	North-west upper purlin	<35	NM	C	-
cnKNG33	North-east upper purlin	75	1.93	26?C	0.28
cnKNG34	South principal rafter, east truss	56	2.82	?h/s	0.27
cnKNG35	South-west upper purlin	51	2.82	h/s+26NM	0.25
cnKNG36	North principal rafter, central truss	62	1.85	24C	0.25

Key: NM = not measured; h/s = heartwood/sapwood boundary; C = complete sapwood, felled during the winter; ¼C = complete sapwood, felled the following spring

FIGURES

Figure 1: Maps to show the location of the King's Arms on West Street in Chipping Norton, marked in red. Scale: top right 1:15000; bottom 1:2000. © Crown Copyright and database right 2020. All rights reserved. Ordnance Survey Licence number 100024900. © British Crown and SeaZone Solutions Ltd 2020. All rights reserved. Licence number 102006.006. © Historic England

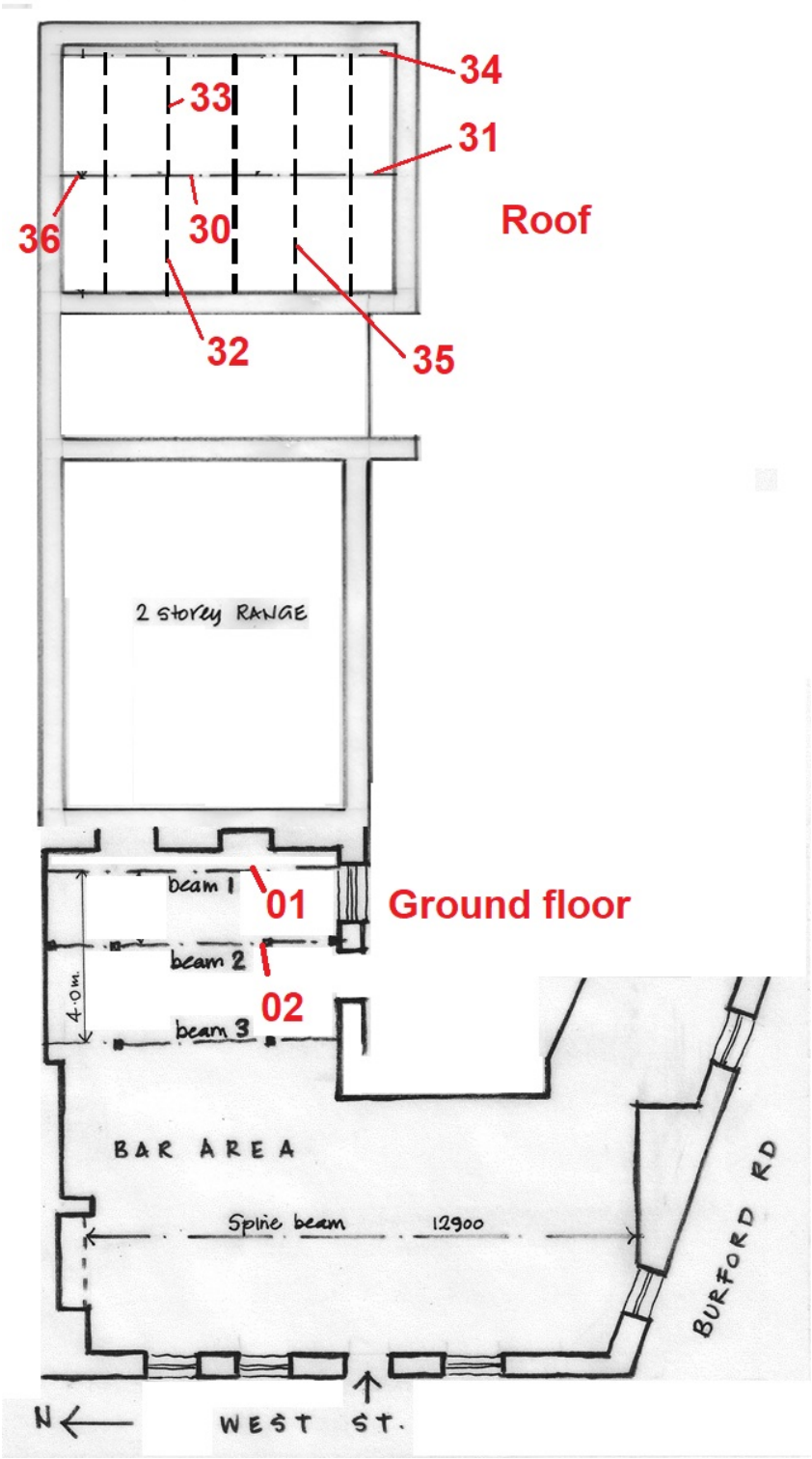

Figure 2: Plan showing the ground floor of the main range with the locations of the two beams sampled in the bar area, along with the sample locations in the roof of the eastern annexe (adapted from an original by Chipping Norton Buildings Record)

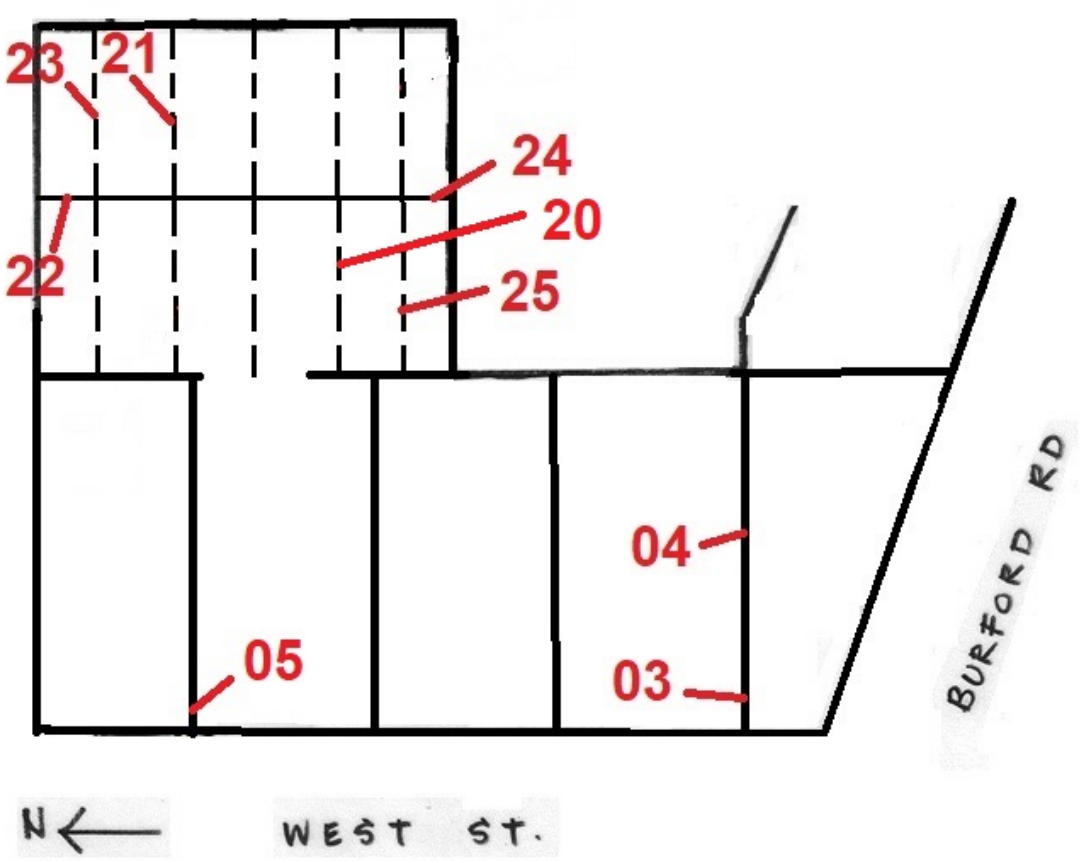

Figure 3: Sketch plan of the attic rooms of the main range and its rear east-west range, showing the approximate locations of the timbers sampled (adapted from an original by the Chipping Norton Buildings Record)

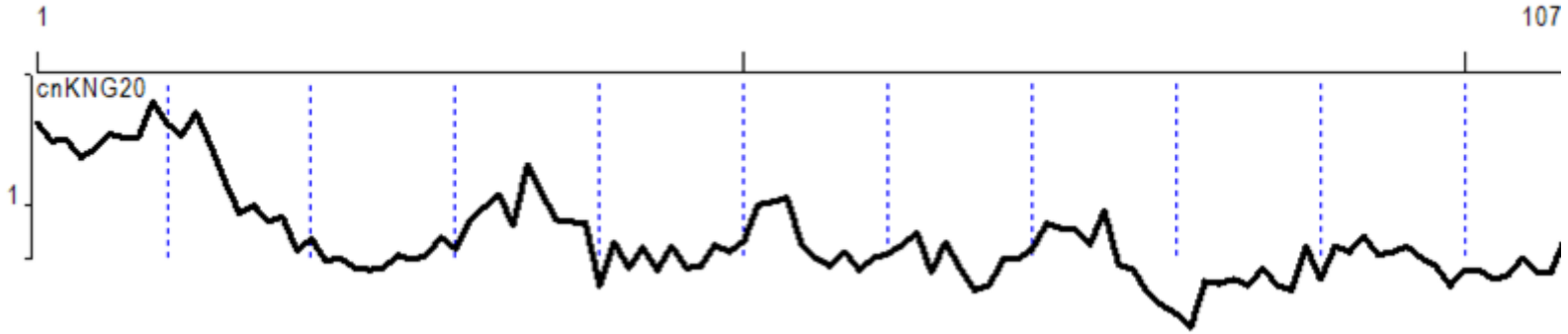

Figure 4: Plot showing the growth curve for sample cnKNG20, highlighting its very narrow rings. The y-axis is ring width (mm) on a logarithmic scale, the x-axis being relative years

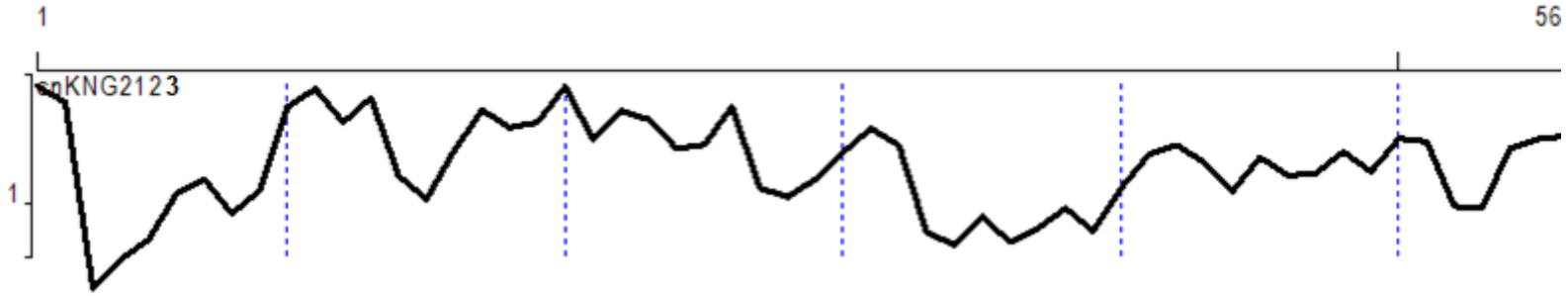

Figure 5: Plot showing the growth curve for the combined series cnKNG2123, showing periods of narrow rings. The y-axis is ring width (mm) on a logarithmic scale, the x-axis being relative years

APPENDIX

Ring width values (0.01mm) for the sequences measured

cnKNG03

509	386	448	310	431	270	293	540	60	52
81	70	100	136	189	206	178	204	208	215
243	259	342	335	253	172	258	230	264	310
304	312	167	129	167	194	236	231	194	213
189	212	249	285	269					

cnKNG20

268	217	220	178	197	236	226	227	346	268
232	306	206	134	91	100	82	87	58	67
51	53	47	46	47	55	52	55	68	59
84	98	114	79	163	115	84	82	81	38
64	47	60	46	61	47	48	62	57	65
101	104	110	62	53	48	57	46	53	56
62	72	45	64	47	36	38	52	52	59
80	76	75	62	93	49	46	35	30	27
23	40	39	41	38	47	38	36	61	41
61	57	69	55	57	61	53	48	38	46
46	41	43	53	45	45	68			

cnKNG21

416	343	36	51	65	113	135	89	118	324
403	268	362	141	106	191	312	252	212	368
154	288	211	159	143	313	99	96	129	157
250	214	68	59	84	78	77	105	69	141
208	291	197	143	220	178	148	233	135	226
230	88	77							

cnKNG22

214	165	181	170	117	161	134	89	111	85
130	162	242	197	511	435	449	379	287	409
425	305	244	238	310	276	250	188	146	107
240	242	156	181	143	172	99	53	67	141
113	130	131	127	162	136	120	79	116	132
80	85	107	59	45	52	63	50	51	48
66	46	54	62	80	63	66	97	78	76
62	51	67	46	40	36	34	46		

cnKNG23

326	463	280	333	345	233	268	335	143	123
142	217	251	195	75	63	88	48	71	85
76	101	156	117	133	90	133	104	142	143
162	216	197	107	113	196	220	228		

cnKNG24

688 612 361 317 217 202 178 150 138 236
200 141 232 119 220 197 170 113 152 191
114 144 127 65 43 52 48 47 46 54
76 49 66 64 68 50 55 58 53 67
42 31 28 31 31 55 34 61

cnKNG25

321 477 360 345 226 360 136 132 159 197
157 141 125 172 253 290 339 510 416 448
467 288 192 109 73 87 62 50 52 28
62 58 59 60 61 71 62 114 101 79
101 119 122 121 235 199 186 222 208 111
74 47 43 77 59 48 47 52 69 117
148 144 216 91 45 42 62 65 62 60
77 109 81 82 80 62 83 112 91 79
82 109 93 101 80 73 40 32 32 40
30 37 69 47 42 18 49 64 65 43
47 39 48 40 39 55 58 47 36 81

cnKNG30

745 891 759 221 62 123 152 138 245 230
239 321 368 444 436 293 463 474 506 432
316 380 475 407 379 421 651 362 424 238
338 305 218 151 65 93 85 68 63 71
75 68 71 78 59 138 132 155 169 195
342 205 158 163 204 195 181

cnKNG33

434 395 376 189 446 540 442 423 357 375
573 443 483 442 426 397 379 131 103 122
124 144 112 183 172 200 248 254 248 321
254 251 214 121 53 59 64 70 79 129
124 121 89 145 154 145 178 252 313 61
46 51 57 31 44 89 92 94 42 83
123 155 57 131 178 169 150 59 96 94
56 44 52 57 61

cnKNG34

302 357 263 364 336 325 345 364 222 257
205 377 401 434 396 238 285 416 519 334
435 370 341 246 309 88 88 69 132 212
268 423 296 217 254 387 212 284 248 149
145 161 211 245 284 312 408 362 287 322
311 355 314 125 65 105

cnKNG35

376 496 569 429 257 508 452 516 451 311
324 352 450 216 333 256 310 292 252 387
146 133 278 327 203 355 272 272 270 309
295 260 321 307 320 311 203 156 211 179
150 126 208 142 129 169 130 182 163 159
180

cnKNG36

441	469	344	455	366	364	238	267	349	127
75	70	85	112	94	119	109	156	186	152
108	177	311	248	179	190	255	237	192	197
322	372	290	451	227	342	378	303	115	86
55	48	67	63	70	88	102	106	108	88
80	65	92	75	71	78	75	81	56	129
129	171								

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ISSN 2059-4453 (Online)