The contributions of Marc Bourzutschky to chess endgame knowledge

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I read in John Roycroft's recent book *Stinking Bishops* that Marc Bourzutschky, with whom I was in regular contact when I was editing *British Endgame Study News* and *Variant Chess*, had withdrawn from chess in 2012, and although he may perhaps at some time return to it as many others have done (he tells me in a recent e-mail that he still follows the game and is interested in any developments on endgames or other items) this seems a convenient moment to summarize his contribution to our endgame knowledge. It will be realised that I can only write about what I know about, and there may well be further relevant material in journals and on web sites which I do not see. What follows will therefore be partial, and perhaps very partial.

My first contacts with Marc were through Guy Haworth, in late 2003 or early 2004. Early computer programs for chess endgame analysis had tended to be restricted to the 8x8 board, and Guy mentioned in the course of correspondence that Marc had a program which could be used, at least in principle, for rectangular boards of any shape and size (there will always be boards which are too large to be analysed on any particular machine). I immediately took notice of this, because I had twice wondered what the result of Q v R might be on other than an 8x8 board. The first time was in 1998, when Paul Byway and I were looking at his Modern Courier Chess played on a 12x8 board. Consider the "Philidor" position with White Kc3 and Qa4 against Black Kb1 and Rb2. On the 8x8 board, White plays 1 Qe4+ Ka~ 2 Qa8+ Kb1 3 Qa4 returning to the same position with Black to move, after which the Black rook has to run (3...Kc1 is no better) and White can soon pick it up. Add four files to the right and Black also has 3...Ri2/j2/k2/l2, and while the first three are easily dealt with the fourth is not. We were indeed unable to find a way of doing so, and conjectured that the ending might be only drawn.

The second occasion was in 2001, when I was examining the book on this ending by "Euclid". I had noticed that some of the winning manoeuvres against a widely separated king and rook appeared to be rather unsystematic, and I wondered if the ending might not in fact become drawn if the board was sufficiently large.

Guy referred both questions to Marc, who quickly came up with the answers. On the 12x8 board, the move 3...Rl2 can indeed be dealt with, though Black can delay the capture until move 23 and in the computer's best-play line the White king twice withdraws from the third rank. Paul and I can perhaps be excused for not having worked this line out for ourselves. Furthermore, although the ending does indeed seem to be "generally won" in that White can always win unless Black can force an immediate mate, stalemate, capture, or perpetual check, there is at least one White-to-move position in which Black can delay the capture of the rook until move 73.

As regards arbitrary square boards, the ending does indeed become drawn on a 16x16 board, though playing it may not be easy (it is generally won on a 15x15 board, so if White plays a line which would win on a 15x15, Black must use one of the extra squares if he is to survive). There are in fact 21 positions of reciprocal zugzwang (Black to move loses, White to move cannot win) on the 16x16 board, one of which (White Kh10 and Ql5 against Black Kb10 and Rg14) has the men so widely scattered that its being reciprocal zugzwang is hardly believable. There are also nine positions of reciprocal zugzwang on a 4x4 board and one on a 3x3, so as far as square boards are concerned this ending is in fact "generally won" only on boards from 5x5 to 15x15 inclusive. Further details, including some specimen "best-play" lines, can be found in issue 44 (May 2004) of *Variant Chess* (pages 51-52) and in the June and September 2004 issues of *British Endgame Study News* (pages 268-269 and 277/280 respectively).

Other endings explored by Marc on non-standard boards include R v B (see *VC* 59, January 2009, page 88), R+B v R (*BESN*, September 2009, page 439), and even R v R (*BESN*, March 2009, page 423, where a charming little reciprocal zugzwang on a 6x5 board is displayed). He also looked into the possible existence of 6-man pawnless full-point reciprocal zugzwangs (whoever is to move loses) on boards smaller than 8x8, and found two on a 6x6 board and one on a 7x7 (*VC* 60, April 2009, page 99).

If I confine myself to the reports which have appeared in *VC* and *BESN*, it is because these are the sources conveniently available to me. There may well be fuller or more authoritative information elsewhere.

As regards endgames in orthodox chess, I was not in contact with Marc when he was working on 6-man endings, but his contribution in that field is mentioned in a brief 2005 report "6-man chess solved" by Guy Haworth in the *ICGA Journal*, volume 28, number 3, page 153, and this in turn refers to a paper "Chess endgames: 6-man data and strategy" by Marc, John Tamplin, and Guy in *TheoreticalComputer Science*, volume 349, number 2, pages 140-157. It was otherwise in respect of 7-man endings, where at one stage I was routinely asking Marc if there was anything new which I could report in the next issue of *BESN*, and a prompt and courteous reply was always forthcoming.

The first 7-man ending to be completely solved by computer was the "Troitzky" ending of 4N v Q. *EG* 156 (April 2005, pages 477-483) contains a report by Marc on this, including the six full-point reciprocal zugzwangs, the longest wins for the knights and for the queen assuming best play by both sides, and a brief description of the methodology. However, this did little more than dot the "i"s and cross the "t"s of Troitzky's 1912 assertion that in general the knights would win, while the presence of four identical pieces subtantially reduced the number of different positions and hence the computing requirements. It was therefore a computing rather than a chess milestone, reached in abnormally favourable conditions, but it was a notable milestone for all that, and it suggested that the computation of more general 7-man endings might not be too far away.

At this point Marc became involved with Yakov Konoval, and all their subsequent work on 7-man endings has appeared under joint names. There was an initial report in the September 2005 issue of *BESN* (page 309), there was a paper "7-man endgame databases" by Marc and Yakov in the composite issue 159-162 (December 2005) of *EG* (pages 493-510), there were further reports in special number 46 (March 2006) of *BESN* (pages 6-8), in the June 2006 ordinary issue (pages 329-332), in *EG* 165 (July 2006, pages 152-154), in the September 2006 issue of *BESN* (pages 342 and 344), in the December 2006 issue (pages 348-349), in the June 2007 issue (page 366), and in the June 2009 issue (page 427), and there was a five-part series "News in endgame databases" by Marc and Yakov in *EG* 185 (July 2011, pages 220-229), *EG* 186 (October 2011, pages 321-330), *EG* 188 (April 2012, pages 122-131), *EG* 190 (October 2012, pages 316-326), and *EG* 191 (January 2013, pages 18-26). These articles were written in Russian by Yakov and translated into English for *EG* by Emil Vlasák, but the first of the series includes a note that Marc had made the final fine tuning, and I presume that the same is true of at least some of the later ones.

This series of articles in *EG* 185-191 provides the definitive survey of the work, but the earlier articles and reports are still worth reading, both for the picture they give of the discoveries as they emerged and for some of the details they contain. The report in *EG* 165 gives all 517 moves of the longest win with Q+N against R+B+N, while at the bottom of page 332 of the June 2006 *BESN* is a convenient list of seven-man pawnless endings where White normally wins even though only one minor piece ahead (see also September, page 344). Previously, all such endings had been assumed drawn unless they involved two bishops against knight, and several studies were upset by the new discoveries. Typically, the composer, assuming that Black needed to gain a second piece in order to win, had arranged for him to do so only at the cost of giving stalemate, and we now know that he can win by declining the immediate capture.

Also of continuing interest are two quotations in *BESN*, on page 309 of the September 2005 issue and page 348 of the December 2006, in which Marc describes the nature of their collaboration. Apparently Yakov wrote the generation program with very little input from Marc, Marc wrote the validation program and a data mining program and also provided the hardware to run everything on, and the generation and validation programs were written completely independently and had only a library of compression routines in common. ("Validation" consists of examining each position in turn, and if for example a White-to-play position is marked "Win in *N* moves", verifying that White can play to at least one Black-to-play position marked "Lose in *N*–1 moves" and not to any position in which he loses more quickly. The satisfying of such a test for every position is a necessary and sufficient condition for a database to be complete and correct.) The results were therefore independently validated as far as is possible when the generation and validation programs are written within the same team.

Nor did Marc and Yakov confine themselves to the Q/R/B/N of ordinary chess. In 2007, they added to their generator the composite pieces "Archbishop" (B+N), "Chancellor" (R+N), and "Maharajah" (Q+N), and found a position with A+N against B+2N where White needed no fewer than 568 moves to force a capture. There is a brief report on pages 99 and 103 of *Variant Chess* 60 (April 2009) which among other things gives two full-point reciprocal zugzwangs with C+A against M (in other words, 5-man full-point reciprocal zugzwangs without pawns), though the 568-move position with A+N against B+2N is not included.

Marc also contributed to the analysis of endgames with composite leapers. In generalized chess, an "*x*,*y* leaper" is a piece which can move to a square *x* away in one direction and *y* away in the other, irrespective of any intervening pieces (so the knight of ordinary chess is a 2,1 leaper). It is well known that a king and two knights cannot in general force mate against a bare king on an 8x8 board. The more general question of whether two *x*,*y* leapers could force mate was looked into some years ago by Václav Kotěšovec, and his results were reported in the Bratislava chess composition magazine *Pat a mat* (issues 19, April 1994, and 30, September 2000); a version in English with minor revisions appeared in the June 2001 issue of the *ICGA Journal* (volume 24, number 2, pages 105-107), and there are summaries in *VC* 60 (pages 99-100) and in special numbers 4 and 24 of *BESN* (pages 4-5 in each case). This little corner of the chess universe had therefore been cleaned up before Marc came on the scene.

However, while what was possible with two *x*,*y* leapers acting in combination had been worked out, what was possible with a single piece having within itself the power of two *x*,*y* leapers had not. A piece having the powers of an *x*1,*y*1 leaper and an *x*2,*y*2 leaper is conveniently called an *x*1,*y*1/*x*2,*y*2 doublet (so the ordinary king, in so far as its movement capability is concerned, is a 1,1/1,0 doublet). It was well known that a king plus a non-royal king could force mate against a bare king on an 8x8 board; what other doublets, with their king, could force mate from a general position, and on how large a board?

This question was clearly amenable to analysis by computer, and Marc duly did so. Noam Elkies came in on this and we all contributed ideas and analysis, but Marc did the computing. (Noam had been in contact with Marc from an early stage, and Marc's report in *EG* 156 ends with thanks to Noam for many useful discussions.) We reported in *VC* 47 (February 2005, page 45).

We then looked at triplets. Marc's 2005 calculations had shown that no doublet could force mate from a general position on a board larger than 16x16, but some triplets can force mate on a board of any size. The identification of these triplets was therefore a natural target for research. This was still in progress when *VC* terminated in 2010, but an interim report appeared in *VC* 64 (pages 210-213), and a final report was posted on the Chess Variants page of www.jsbeasley.co.uk in December 2014. There are still gaps which need to be filled if the analysis is to be made completely rigorous, but we are now satisfied that we know which triplets, with their king, can force mate against a bare king however large the board may be.

From a computational point of view, this exercise may have been even more demanding than the 7-man endgame calculations. The deepest 7-man ending examined (A+N against B+2N) took 568 moves; the deepest triplet ending calculated (a 3,2/3,1/2,2 triplet on a 128x128 board) took no fewer than 13,077 moves, and two others took over 10,000. Runs of this length take months rather than weeks, but fortunately the calculation proceeds by levels, which provide a natural restart point every quarter of an hour or so. So even if somebody trips over the power lead, the resulting loss of time is not great.

All this was done on home computing equipment. Previous leading-edge chess endgame analyses had taken advantage of university or other institutional equipment; furthermore, most if not all had been done in the course of a normal working day, either by a postgraduate student as part of a thesis for a higher degree or by a member of staff who could claim with at least superficial plausibility that it formed a proper part of his research work (Lewis Stiller's report on his pioneering multi-processor 6-man endgame analysis, in the book *Games of No Chance*, acknowledged a support grant from the U.S. Army). Marc worked as an amateur, providing his own equipment and doing everything in the time left over by family commitments and a normal full-time job.

It has been a notable achievement.