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We study the analogues of symmetric spaces for the family of dicyclic groups of order $4n$. We investigate the structure of the automorphism group, characterize the involutions of the automorphism group, and determine the fixed-point group and symmetric space of each automorphism. Moreover, we determine the structure of the orbits of the symmetric space when the group and fixed-point group act by twisted conjugation. Finally, we describe the isomorphism classes of automorphisms and involutions. (Received September 25, 2012)